RENAL AFFECTIONS.

RENAL AFFECTIONS:

THEIR

DIAGNOSIS AND PATHOLOGY.

BY

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TO

DAVID STEWART, M.D.,

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This little Work

IS AFFECTIONATELY INSCRIBED,

IN ACKNOWLEDGMENT OF THE MANY FAVOURS

RECEIVED AT HIS HANDS

BY

THE AUTHOR.

PREFACE.

The design of the following little volume "On the Diagnosis and Pathology of Renal Affections," was suggested to the author some time since, by the difficulty he experienced in referring medical students to some more elementary work than now exists on this branch of Pathology; and a greater part of the present volume consists of the notes that were written from time to time to aid the studies of those under his care. Having within the last few years paid particular attention to this branch of animal chemistry, he has thought, that the mode and results of his investigations arranged in what he thinks a more intelligible form than those presented to the public some few years back, might not prove unacceptable to those members of his profession, who have wished to devote themselves to the study of Urinary Pathology, and who have been deterred from the pursuit by the formidable array of chemical changes, and the innumerable varieties of crystalline formations.

It has occurred to the author, that the reason this subject is generally found to be distasteful to beginners, is owing in a great measure to the arrangement of the different works; in a majority of them the account of each component article of the secretion is entered into separately, and so the reader is required

to go through the entire book, before he is able to make an examination of the most simple specimen. This defect he has endeavoured to remedy, and in the first chapter, therefore, are laid down directions to be pursued when a superficial examination only, is necessary. In the next, rules for a more exact analysis, and so on, progressively in the following chapters, so that the student may commence with the more simple cases, and go on by degrees to those requiring greater accuracy of observation. At the same time, as he wishes to avoid conveying a mere empirical knowledge, the rationale of each step and the indications it affords will be explained in turn.

He of course, does not assume that all the matter contained in the text is original, but believes, that in every instance he has given due credit to the labours of those who have preceded him, and as every observer, however honest, is liable to err, he will at any future time gladly modify the opinions herein recorded, should more extensive observation prove his results to be incorrect.

In conclusion, the author would remark that, with some few exceptions, the figures accompanying the text have been copied by himself from the field of the microscope.

Baltimore, Md., October 1850.

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INTRODUCTION.

In all bodies endowed with animal life two processes are constantly going on, namely, waste and reparation; but the relation of these to one another varies at different ages of the individual's growth. In an animal arrived at maturity, these processes nearly equalize one another, while in early life, the addition of new material, in the form of vitalized tissue, more than counterbalances the waste that is produced by their disintegration. Both these changes are effected by the influence of oxygen; and of the substances thus formed, those destined for elimination are carried with the circulating fluid to the different excreting organs, each of which abstracts from it those materials, fully formed, which it is its province to excrete. The lungs and skin perform a part of the function allotted to them by ridding the economy of carbonic acid, while the kidneys are the emunctories by which the effete matter, produced during the decomposition of the tissues, as well as those substances that can take no part in the animal economy, or whose retention would be injurious, are eliminated from the system; and it is in the secretion of these organs, therefore, that we are principally to look for any derangement in the

function of digestion, or of mal-assimilation in the processes of disintegration. For this reason a certain degree of attention has always been paid to the appearance of the urinary secretion, but it has only been within the last few years that investigations founded upon a scientific basis, have been made with a view of ascertaining the alterations that it undergoes in different abnormal states of the system; for, like all the excretions and secretions of the animal body, this fluid has a healthy standard, and any departure from it indicates some morbid condition in one or more of the other functions. But we have as yet only arrived at the threshold: the few facts already ascertained, although affording very material assistance in the diagnosis and treatment of some obscure affections, constitute but a small portion of the immense field laid open for future researches.

The objections that have been urged against Chemistry in its explanation of the various phenomena that take place in the animal body, as omitting in all these operations the influence exerted by the vital power, cannot be sustained when its laws are adduced to explain the physiology and pathology of the urinary secretion. For we are well aware that the presence of the different ingredients entering into this secretion is almost entirely due to the processes of eremacausis or decay. If vitality had continued in force, this change could not have taken place, and it is only when the influence of this power is entirely removed from the different particles entering into the composition of the tissues that chemical phenomena can be brought into play

and effect the formation of those substances whose elimination is the principal function that nature purposed the kidneys to perform. With the exception therefore of the therapeutical indications, we are dealing entirely with effete matter, whose domain is far removed from the influence of vital laws.

The physiology of this secretion in all its bearings, even at this time, is not entirely explained, and it can scarcely be a matter of surprise that many incorrect ideas should be prevalent among those who have given to this subject but little of their attention. Three of these opinions we have found to be very universal even among medical men, all of which are decidedly erroneous, and it shall be our first care to explain them away. In the first place, that an abnormal condition of the urine is always associated with some defect functional or organic of the kidneys; secondly, that a deposit is always indicative of an abnormal state of the secretion; and what is of more importance still, that a healthy appearance of the urine cannot be associated with an unhealthy condition of that fluid. In regard to the first of these opinions the fact is, that the urine is never indicative of the physical condition of the kidneys any more than the blood is of the state of the heart except in two instances, and these are where it contains pus, or some of the elements of the circulating fluid, as albumen, liquor sanguinis or blood; in all other cases the foreign materials present are dependent on mal-assimilation, either of some article of food or of the tissues entering into the composition of the body, or are derived from the ureters and coat of the

bladder. In the second place, a deposit may very frequently occur from a precipitation of some healthy ingredient, by subjecting it to a lower temperature or to evaporation, or from decomposition where new elements are formed as will be explained hereafter; thus, when a portion of healthy urine is subjected to the air-pump, a dense cloud is formed almost immediately from the precipitation of urate of ammonia which is no longer held in solution when evaporation takes place, and the same result frequently occurs on any decided diminution of the temperature; thus during the winter healthy urine passed at night, and perfectly clear, from this cause often contains a sediment in the morning. Again, in the third place, the urine may be loaded with albumen or sugar in solution, and yet present a perfectly healthy appearance on a casual examination, or even with oxalate of lime in crystals, which from their property of refracting light in a peculiar manner, are not discoverable until a drop of the fluid is placed under the field of the microscope.

The normal constituents of the urine being dependent upon many different circumstances, such as the season of the year, the different periods of the day, and the kind of aliment used, it is impossible to lay down any exact standard of its composition which will be applicable in all cases, and in the examination of every specimen all these conditions must be taken into consideration. In the first place, just in proportion as the secretion of the skin is greater will that of the kidneys be less, so that an excessive or diminished secretion cannot in itself be regarded as an evidence of

disease. Thus we find that a greater amount of urine is passed in the winter than in the summer; consequently, although we may find the relative amount of solids in two specimens to be very different, yet the absolute amount in regard to the whole quantity voided in twenty-four hours will be exactly the same. It has also been found that the average specific gravity of the urine passed at night is much higher than that passed in the morning, and it frequently occurs than an abnormal salt is present at one of these periods, and yet wanting at another, so that in all cases, unless an average of the whole passed in twenty-four hours be examined, we may be led into an important error.

The most frequent deposit met with in the urine is urate of ammonia, and its importance depends very much upon the fact whether it exists in a state of solution or not at the time of emission. Nearly all urine contains a greater or less amount of this substance, and as it is formed by the uric acid uniting with ammonia, derived either from decomposition or deficient action on the part of the skin, it is evident that it may be indicative either of one of these conditions, or merely of the amount of uric acid in the urine; and it becomes of great importance when it is present in so large a proportion as to be deposited while the secretion is still in the bladder. If it exists in any excess, a deposit of it occurs when the urine becomes cool from its being less soluble in cold than in warm water; and in cold weather, as just stated, we often observe it deposited from this cause in the morning in the urine passed the previous night; and again, as one of the functions of the skin is to

eliminate ammonia, a sudden check of perspiration is often followed by a deposit of this salt in the urinary secretion. It is also frequently met with in urine passed soon after taking a full meal. This is because the oxygen that should have been used for the conversion of the uric acid into urea, has been appropriated by the system to effect the necessary changes in the food by the formation of carbonic acid and water. In this way an excess of uric acid remains unconverted into urea, which excess by uniting with ammonia derived from various sources forms a deposit if the quantity of water be insufficient to dissolve it, or the temperature undergoes any decided diminution. But this will be more fully explained at another place. In any fluid containing urea and uric acid, a deposit of this salt is apt to occur after a time from decomposition. Urea resolved into its ultimate elements consists of carbonic acid, ammonia and water, and as this resolution takes place, the ammonia often unites with the uric acid to form urate of ammonia, while carbonic acid is given off. We are thus shown that the longer the period that elapses after the discharge of the specimen submitted for examination, the more unfit it is for exact analysis.

It will be found that, with the exception of sugar and albumen, neither of which exist in healthy urine, the relative proportion of the different ingredients is of little direct importance when they exist in a state of solution, except as indicating the derangement of system under which the patient is suffering. The quantity of phosphates, carbonates, urea, and uric acid is influenced very much by the

kind of aliment used, and the amount of oxygen taken in, and whether they are deficient or in excess, their presence produces but slight inconvenience so long as they remain in solution.

There are various modes of appreciating the properties of the urinary secretion, but they may all be included under three heads,—the physical, mechanical, and chemical. The first of these relates merely to those properties which can be detected by the use of the unaided senses, such as colour, odour, opacity, &c., and to these we have confined ourselves in the first chapter. The second enables us to ascertain the density of the urine, the proportion of solid contents to the water, and to one another. By the third, we learn what these different ingredients are composed of, and thus ascertain the normal amount of healthy substances, or the existence of abnormal elements. To these are also added the assistance afforded by microscopic observation, which often enables us at a glance to detect the existence of some abnormal product after all other means have failed. Each of these will be considered in detail.

It is not to be supposed that these different modes of exploration can in any degree do away with close observation of the other symptoms of the diseased state under consideration, any more than auscultation makes an examination of the general symptoms of diseases of the chest unnecessary; nor must it be imagined that an exploration of the urine is of assistance in all diseases. It is as a general rule an addition merely to symptomatology, and has already been found an important aid in the diagnosis of

some obscure dyspeptic complaints, in many of them affording what might almost be termed a pathognomonic symptom. And as in making up a diagnosis, each organ and its functions should be in turn subjected to an examination, until we are satisfied as to the location of the disease, we shall endeavour to lay down in the following pages some directions by which the presence of the different normal and abnormal ingredients in the urine may be detected, with their relative importance and pathological signification.

RENAL AFFECTIONS.

CHAPTER I.

PRECAUTIONS TO BE OBSERVED IN OBTAINING A SPECIMEN OF URINE, WITH INSTRUCTIONS FOR A SUPERFICIAL EXAMINATION AT THE BEDSIDE.

The urine voided at different periods of digestion and assimilation, possesses different properties, which for convenience have been arranged under separate heads,—these are called urina chyli, urina sanguinis, and urina potus. The first generally contains some of the physical or chemical substances of the food that have not been assimilated in the process of digestion; the second, those elements of disorganization which are derived from the tissues which can no longer subserve any purpose in the economy, and are consequently carried off by the kidneys after first passing into the blood; and the third, which constitutes by far the largest source of the secretion, is derived from the watery portion of the fluid potations which are constantly taken into the system. Now, as the derangement which

produces an abnormal condition of the urine may be resident in but one of these sources, it is evident that an examination made of a portion of it passed at one period of the day may contain no abnormal ingredient, while in that voided at another, ample evidences of a diseased condition will be found. For instance, an abnormal condition of the urina chyli which is wanting in the urina sanguinis, points to some error in digestion, and would be most perceptible in the urine passed a few hours after the principal meal; while any departure from the healthy standard in the urina sanguinis indicates a fault in secondary assimilation, and would be most apparent in that portion of the secretion passed on first rising in the morning. It is therefore necessary that the examination should be made at different periods of the day, or that an average of the whole should be taken. For all practical purposes it will be sufficient to take an average specimen of that passed on going to bed and on rising in the morning, or if we wish to be more exact, to examine these specimens separately. In a more superficial examination, however, such as we are at present detailing, if the patient be intelligent, it will be sufficient to rely upon his assurance for its character and appearance, unless the diagnosis of the case be obscure, or there are symptoms leading us to suspect derangement of the urinary organs.

We first ascertain whether the urine is passed frequently, and if so upon what this frequency is dependent. "Frequent calls to urinate may be owing to a large increase of the renal secretion, and when attended with pain to a con-

centrated state of the urine, to inflammation of the bladder, to the ingestion or absorption of the active principle of cantharides or of turpentine, to the presence of a calculus in the bladder, to enlargement of the prostate gland, to pressure of some adjacent organ or tumour, and to an excited state of the nervous system."* If it is to the first of these causes, it will be dependent either upon the previous ingestion of large quantities of fluid, to hysteria, or to the fact of its containing sugar. The last of these three may be suspected when it cannot be traced to either of the other causes, when there is emaciation and inordinate appetite, or when the disease is of a chronic form. If the frequency is owing to any other of the above-mentioned causes, appropriate symptoms will easily lead to its detection.

Our attention is next directed to ascertain if retention of urine exists, or if it is voided at longer intervals than usual. Infrequency in passing urine is owing either to its being scantily secreted by the kidneys or to its retention in the bladder. In the first case the whole quantity passed will be less than in a state of health, and is owing either to inordinate action of the skin, or to some cause which interferes with the secreting function of the kidneys. If the condition is an acute one, it is most probably due to congestion or inflammation of these organs, and if chronic to granular degenerescence of the cortical portion. Infrequency, dependent upon retention in the bladder, is owing either to some physical cause which prevents its escape, or to the nervous sensibility of the patient being so blunted that the

* Stillé's Pathology, page 286.

presence of the urine gives rise to no sensation, and thus allows it to accumulate in the bladder.

Our attention, in the third place, is directed to the appearance of the urine. The healthy secretion, in colour, although generally of an amber hue, depends in a great measure upon the amount of concentration it has undergone, and in many cases to the ingestion of different articles of food. Thus it is darker in summer than in winter, because more fluid is secreted by the skin, and consequently less by the kidneys, and it is also said to be darker in men than in women, from the fact of the former taking more exercise and thus increasing the amount of the cutaneous exhalation. Pereira brava, hæmatoxylon, and beet-root, have the property of rendering the urine deep brown and red, rhubarb yellow, and indigo gives it a bluish tinge. Nervous affections and anæmia render it pale, while in febrile disorders it becomes darker. The following appearances as indicative of particular conditions may also be remarked. If it is of a deep yellow or orange colour, we may suspect bile; if citron coloured or yellowish-green, oxalate of lime; if of a pale straw colour with a bluish-green tint and having the odour of whey, sugar; if it is transparent when warm, but forms a deposit on cooling, lithate of ammonia; while if it is pale and cloudy when passed and becomes opaque on the addition of a few drops of vinegar, we may suspect albumen. But after all, so long as the secretion retains its transparency and is perfectly free from sediment, the practical indications to be derived from its colour are of little importance. After taking turpentine for some days, the urine in many cases assumes an opaque and

milky aspect, but soon clears up when the remedy is discontinued. The presence of blood in the urine is indicated when the secretion is opaque and of a dirty brown, red, or black colour, and of pus when it is of a dirty yellowish-white; but both of these will interfere with the transparency of the secretion, and if the vessel containing the specimen be allowed to stand, will form a sediment,—the first as a flocculent and easily-diffused mass, and the second resembling a layer of cream or oil.

We stated that urate of ammonia was often found existing as a deposit, sometimes as a result of decomposition, and at others before this had taken place. When not owing to decomposition or to a diminution of the temperature, it is principally indicative of some impairment of the functions of the skin, by which ammonia is retained in the system and uniting with the uric acid passes off as urate of ammonia. Its diagnosis is very simple: being perfectly soluble in warm water, we have but to heat the suspected urine by warming the vessel containing it, when it almost immediately clears up, to be deposited when it again cools.

The odour of the urine is influenced by articles of food and by different medicines, as asparagus, onions, garlic, juniper-berries, assafœtida, and copaiba. When sugar is present the odour is first that of whey, and then of alcohol, and when decomposition has taken place it is strongly ammoniacal.

Urine may be perfectly healthy in appearance and yet contain albumen, sugar, or oxalate of lime. The first of these is readily recognised at the bedside. We suspect the

presence of the second when an unusually large quantity is passed habitually, attended by thirst and emaciation; and the third is indicated by great depression of spirits, inability for mental or physical exertion, together with pain in the back and along the course of the urethra.

After observing the colour, odour, &c., of the specimen, our next proceeding is the application of heat. This is readily done by immersing some of it, contained either in a spoon or a vial, in hot water, or holding it over a lamp. By this means we detect the urates, albumen, and the phosphates. The first are dissolved, the other two deposited. Albumen and the phosphates are readily distinguishable from one another by the appearance the deposit assumes, the first being gelatinous, and the other crystalline.

The preceding directions constitute all that can be given for an examination at the bedside. They can do little more than point out whether there be any necessity for further examination; and this should always be made when any peculiarity about the appearance of the secretion will allow us to suspect the presence of an abnormal ingredient. We would moreover remark, that inasmuch as albumen, sugar, or oxalate of lime may be present in small quantities, without producing any change in the appearance of the urine, or giving rise to any particular symptoms local or general, which would lead us to suspect them, we will scarcely have performed our duty to the patient, unless an examination for one or all of these substances be made in every case of disease where the symptoms are obscure, and the diagnosis uncertain.

CHAPTER II.

DIRECTIONS FOR A MORE EXACT EXAMINATION OF THE DIFFERENT INGREDIENTS OF THE URINARY SECRETION.

Necessity of examining a specimen of Urine soon after it is passed—Specific Gravity, the indications it affords—Temperature necessary to be observed—Reaction—To advance further, two modes of examination may be used, the Microscope and Chemical Tests—Have confined ourselves in the present chapter to the last—Estimation of the Urea—Uric Acid—Hippuric Acid—Phosphates—Mucus—Albumen—Blood—Pus—Sugar—Oxalate of Lime—Cystin—Bile—Kyestein.

It will be seen by the preceding chapter, that all the information afforded by an examination of the urine at the bedside, can do little more than indicate to us the necessity of further examination, or otherwise. If the diagnosis of the disease under which the patient is suffering be evident, and the urinary secretion is natural in appearance, there will be little necessity for proceeding further; but if the reverse is the case, we should, in all instances where it is practicable, obtain a specimen for more exact observation. The same precautions in selecting it are to be observed as before, taking care that the examination is made as soon as possible after voiding it. We explained previously, how readily urea became resolved into carbonic acid

and ammonia from decomposition; and from the same cause, after allowing a vial of urine to stand for some days, or even for twenty-four hours, we may often observe prisms of the triple phosphate formed by the ammonia uniting with the phosphate of magnesia, and occasionally crystals in the form of dumb bells, under the field of the microscope, which did not exist at the time of emission, thus evidencing the inutility of an examination after decomposition has taken place.

Having observed these precautions, our first step should be to ascertain the *specific gravity.* This is done either by means of a specific gravity bottle, a urinometer, or by filling a vial, the weight of which is known, first with distilled water, then with urine, and dividing one of these weights by the other. Of these different means the urinometer is by far the most convenient; it is exceedingly simple in its construction, and its mode of application is obvious on inspection. The specific gravity of healthy urine varies between 1·022 and 1·028, and is greater in summer, when a large amount of fluid is passed off by the skin, and consequently less by the kidneys, than in winter. The amount voided by a healthy individual varies, for the same reason, between twenty-five and thirty-five ounces. We can readily understand then, that although the same amount of solids may be passed each day, the specific gravity will differ in proportion to the quantity of water in which they are dissolved. If therefore it should vary much either above or below these numbers, the amount of fluid passed remaining normal, we should be led from this

cause alone to make further examination. This step is not absolutely necessary, but it will be found, in many instances, to afford us very material assistance.

It is also of importance, in many instances, to ascertain the *temperature;* and for this purpose, in some of the boxes intended for urinary examination, a thermometer with an elongated bulb is added. There are many substances which remain dissolved at a certain temperature, but are precipitated at a lower; and in this way the specific gravity may become altered.

We next proceed to test the *reaction.* Healthy urine is always acid, and this probably depends not on any free acid existing in the secretion, but on some of the phosphatic salts which have an acid reaction. If litmus paper is changed from blue to red, showing an acid state of the urine, we gain merely negative results, but if changed from red to blue, indicating an alkaline condition which cannot be accounted for by decomposition or alkaline remedies, or some acute disease of the brain, we have reason to suspect the presence of albumen.

After ascertaining the specific gravity of the specimen under consideration, we apply heat by means of a spirit-lamp until boiling commences, to a small quantity of the urine contained in a test-tube. By this means we detect urate of ammonia, albumen, and the phosphates. The first of these is dissolved by heat, the two latter precipitated. The detection of urate of ammonia has been already detailed in the first chapter; the distinction be-

tween the two others will be explained at an appropriate place in the present.

For further proceeding, two different modes are brought into play,—chemical tests and the microscope. Neither of these can take the place of the other, but each serves to substantiate the results previously obtained. All specimens of urine submitted for examination, and allowed to stand for a few hours, are found to be either clear, or containing a deposit. If clear, chemical tests alone can afford us an insight into their condition; but if a deposit exists, their nature can be much more easily determined by the aid of the microscope; and in the present chapter we shall confine our remarks to the use of chemical tests alone. We stated in the introduction, that with the exception of sugar and albumen, there were no substances that gave rise to decided therapeutical indications, so long as they remained in solution in the urine; but still these substances are of importance in pointing out the particular diathesis, and thus enable us often to ward off a direct attack of disease by timely treatment. For instance, in a gouty individual, however large the quantity of uric acid may be in the urine, as a general rule there will be no paroxysm, so long as it remains in solution, but still this excess is an indication to us for preventive treatment. We say as a general rule, for it occasionally happens that the blood is loaded with uric acid, while the urine contains but a small quantity. This may be owing to simple congestion, or some other functional defect of the kidneys; and an attack of gout then takes

place, without any absolute excess of acid. But this will be explained more fully in its appropriate place.

The qualitative estimation of the *urea* is the first substance we take into consideration. Urea combines readily as a base with nitric or oxalic acid. The first is the one generally used for its detection. A small quantity, say about a drachm, of the urine is placed in a watch-glass; to this an equal bulk of nitric acid is added, and the mixture allowed to stand, taking care that the temperature is at a proper medium, for if it is too cold, crystallization is accelerated, and if too warm, retarded. We should endeavour to allow the acid and urine to mix gradually, and instead of pouring them quickly together, we should by means of a pipette, or a small glass funnel, placed on the bottom of the watch-glass which already contains the urine, allow the acid to mix gradually from below. We sometimes see crystallization commence almost immediately, indicating a very decided excess of urea, provided the amount of urine passed was normal from which the specimen was obtained. If, however, at the end of half an hour we observe only a few crystals around the edges, and a few air bubbles on the surface, we conclude the amount to be either normal or deficient. This proceeding is an approximative one only, as we do not purpose to go into a lengthened detail of the exact quantitative analysis of these different elements. Should albumen be present in the urine, its precipitation on the addition of nitric acid would prevent us from ascertaining the amount of nitrate of urea formed. This is to be remedied either by coagulating the albumen

by heat, or precipitating it with alcohol, then filtering and proceeding as before.

Occasionally we may wish to isolate the urea from the other elements in the urine. This may be done by a very simple process. Evaporate very slowly a given quantity of urine to the consistence of syrup, and add gradually an equal bulk of nitric acid, taking care that the mixture be kept cool. After a few hours the vessel will be filled with crystals of nitrate of urea, which may be collected on a filter, if washed carefully from time to time with a few drops of diluted nitric acid. Dry these crystals by means of a gentle heat, then dissolve them in distilled water, and neutralize the solution by means of carbonate of potassa. By this means nitrate of potassa is formed, carbonic acid given off, and the urea liberated. Evaporate this solution by means of a gentle heat to dryness, and add boiling alcohol. This extracts the urea, which may be obtained in pure crystals by allowing the alcohol to cool and evaporation to take place.

The next substance for examination is the *uric acid*. This acid exists in all healthy urine, and bears a proportion to urea of about one to thirty-two, so that about eight grains are passed daily from a healthy individual. Nitric acid, although frequently used for the detection of uric acid, is liable to induce error, for although it first precipitates it from its combinations and takes its place, yet if more be added, as an excess has the property of dissolving uric acid, we may easily redissolve all that had been previously thrown down. This is remedied by substituting hydrochloric acid, in which it is insoluble. The deposit

will consist of fine reddish grains, easily distinguishable by the naked eye, coating the sides as well as the bottom of the test tube. But as these grains are sometimes so minute as to escape detection, it will be well in all instances to use a small feather along the sides of the test tube, which detaching the crystals, allows them to fall to the bottom, where their quantity can be more easily appreciated.

Should there be any doubt in regard to the nature of the deposit either existing originally or deposited with acid, we should take a small quantity and add to it a drop of nitric acid, then evaporate this by a gentle heat, and on holding it over the vapour of ammonia, if it consists of uric acid it becomes a rich purple colour. This is the murexid of Liebig. The most convenient way of performing this is to dissolve the acid in a watch-glass in a few drops of nitric acid, evaporate this, and then invert it over another watch-glass containing a few drops of strong ammonia. By applying a gentle heat, the rich purple colour will be perceived in the upper glass. Heated with liquor potassæ, uric acid is readily made to dissolve from the formation of urate of potash. The specific gravity of urine containing an excess of uric acid is generally above the average, it is always acid, and usually of a deeper amber tint than natural. In a small test-tube containing about half an ounce, the normal amount of this substance precipitated by hydrochloric acid would not be more than sufficient to cover lightly the bottom of the vessel. If we observe but a few crystals after allowing the specimen to stand for some hours, for it does not form immediately, we conclude that

this element is deficient, and vice versa. If the deposit occur spontaneously, we must not always infer that it is owing to an excess of this acid, unless we find at the same time an unusual amount held in solution, for an increased quantity of any of the other acids, particularly phosphoric, will, under certain temperatures, precipitate uric acid.

Another organic acid, which of late years has been proved to exist in healthy urine, is the *hippuric*. Its detection is more difficult than uric acid, and the practical inferences to be derived from it are of much less importance. The following is the mode recommended by Dr. Day. "Evaporate the urine till there is a copious deposition of salts. Add strong alcohol, and place the mixture in a stoppered bottle. With the aid of a gentle heat (for instance, by placing the bottle in warm water), we insure the solution of the urea and the hippurates in the alcohol, while the urates remain with the insoluble constituents. When the supernatant fluid is perfectly clear it must be decanted, evaporated nearly to dryness, and redissolved in hot water. By gradual concentration and the addition of a little free mineral acid we obtain crystals of hippuric acid." This proceeding is laborious when compared with that necessary for the detection of the other elements; but in some cases where it exists in considerable excess the mere addition of muriatic acid throws it down in large quantity, but a certainty as to its nature and its diagnosis from uric acid can only be arrived at with the assistance of the microscope.

We next proceed to the detection of the *earthy phosphates*.

This is done by adding a few drops of ammonia, taking care that there be enough to render the urine at least neutral. These salts are never entirely deficient, and almost immediately after the addition the specimen becomes turbid from the deposition of the triple phosphate and the phosphate of lime. In a test-tube, containing about half an ounce, the normal amount, provided the usual quantity of urine be passed, would occupy nearly one-fifth of the lower part of the tube after standing a few hours. If it is wished to separate the phosphate of magnesia and ammonia from the phosphate of lime, it is readily done by adding a few drops of acetic acid, which dissolves the first. This deposition will also take place on the application of heat, if they exist to any great excess, but they are dissolved again immediately on the addition of nitric acid. This may be explained by the well-known chemical principle, that when substances exist in a fluid in so large a proportion as barely to be held in solution, almost any mechanical cause which produces a sudden change in the relation of the particles to one another induces precipitation, and violent agitation such as shaking the tube forcibly, will often produce the same result. If these salts should exist as a deposit, they are easily recognised by being nearly always white, and on holding a drop of fluid containing them near a candle or in the sunlight, there may be observed a peculiar glittering appearance which belongs to them almost exclusively, although the same thing is sometimes observed with a deposit of uric acid, but the last is of a reddish orange colour, while the phosphates are always

white. Another mode of detection when both salts are present is their fusibility: neither phosphate of lime nor the triple phosphate are changed under the blowpipe, unless a very great degree of heat be used, but when united in about equal proportions they are easily fused into a white enamel. This property has gained for the calculi composed of the two united, the name of the fusible calculus. They are also perfectly soluble in hydrochloric acid.

A small quantity of *mucus* is present in all healthy urine, and in certain diseased conditions is found in considerable quantity; its detection is generally easy. Mucus contains no albumen, and therefore will not coagulate on the addition of heat, and is always found in irregular gelatinous masses with air bubbles entangled. If, however, there be a large quantity of phosphates present they will give it a more opaque appearance. It sometimes happens that on adding nitric acid to a specimen of urine, we observe a copious white flaky deposit occurs, which immediately clears up on heating it. This we have observed in only a few instances, and have found it invariably to consist of mucus in excess.

The directions in this chapter thus far relate entirely to those ingredients which exist normally in the urine; we will now consider the mode of detecting those which are found coexistent with an abnormal condition. The first of these is *albumen*. The detection of this substance is very easy. Albumen coagulates on the application of heat, and is deposited by the addition of nitric acid and alcohol. It exists

as an albuminate of soda, from which combination the acid precipitates it on account of its affinity for the soda, and the alcohol for the water, which holds it in solution. This coagulation by heat may be observed in a spoon or a simple vial; yet if the quantity be very minute it may escape observation when these means only are used. A small glass test-tube heated over a spirit-lamp, or plunged into boiling water, will obviate this difficulty, and should therefore be used. The white cloud formed under these circumstances is due either to the presence of albumen, or to an excess of phosphates. These latter are only deposited by heat when they are in so great an excess that anything which disturbs the relation between them and the water in which they are dissolved, causes them to be precipitated. Heat acts in this way, by increasing the space between the atoms of water, and also by producing currents in different directions. But as we before remarked, the nature of the deposit, as well as its solubility or insolubility in nitric acid, allows us readily to distinguish between the two. The deposit in the first case is flaky, in the second crystalline; and phosphates are soluble in nitric acid, while albumen is insoluble.

We must not however always conclude that when heat produces a deposit which nitric acid dissolves, that the precipitate is necessarily albumen; for in many cases if a drop or two only of the acid be added, albumen will be dissolved as well as the phosphates; but the difference is easily ascertained, for on adding a few drops more the albumen is thrown down while the other remains in solution. It often

happens that nitric acid is used for the detection of this substance, and it is well that the errors likely to be induced by its employment should be understood. In the first place if the urine be alkaline, no precipitate will occur until it is rendered acid, and it will therefore require that sufficient acid should be added to give the urine an acid reaction before a deposit will take place. Dr. Rees has also observed that while taking copaiva a substance is deposited from the urine on the addition of nitric acid, which resembles albumen in almost every respect, and it is also said that in some states of fever, uric acid of a white colour and resembling albumen very much, is often deposited on adding a few drops of nitric acid. This again may be distinguished by heating the specimen, when if albumen be present coagulation takes place.

The next thing for our consideration is to ascertain whether *blood* be present. This principle is most frequently found in a state of solution in the urine, the fibrin and globules being perfectly separate. In proportion to the amount of it present will the secretion be more or less of a reddish colour, and if it be allowed to stand, a reddish opaque deposit will soon form. On heating the urine, the albumen of the serum coagulates and the red colour changes to a chocolate. Its detection is generally very simple, for although hæmatoxylon, purpurin and beet-root give to urine nearly the same colour as blood, yet no change takes place on heating a specimen containing them. Should blood exist as it occasionally does in coagula, their appearance is at once sufficient for its recognition.

Pus is another abnormal element, which under certain conditions makes its appearance in the urine. When unmixed with either blood or mucus, and if it exists in any quantity, its detection is by no means difficult. Urine containing pus is always somewhat turbid when passed, and if it be allowed to stand, the upper stratum becomes clearer from the subsidence of the purulent matter, but never perfectly transparent. The reaction is generally either acid or neutral; if alkaline, the nature of the deposit is entirely changed. Pus contains both fat and albumen, and although unchanged by the action of acids, has the property of becoming gelatinous on the addition of ammonia or liquor potassæ. This last change frequently takes place from the ammonia generated during decomposition, although, as a general rule, this fluid is less apt to decompose when it contains pus, than under other circumstances. If we suspect the presence of pus, the best mode of arriving at a certainty is as follows: after allowing the urine to stand for some hours, pour off the supernatant fluid, heat it over a spirit-lamp, and observe whether coagulation takes place; separate the remainder into two portions; to the one add ammonia, and to the other ether. Ammonia renders the first gelatinous, by uniting with the fatty matter present; and ether takes up the fat, which may be obtained in globules, by pouring it off and evaporating. If a small quantity of pus be mixed with a large quantity of mucus, its detection is almost impossible. The following peculiarities may however be of assistance. If mucus contains air-bubbles it will float, while pus always sinks. Mucus lying

in water appears as a homogeneous streaked viscid and tenacious mass, of a white or whitish-yellow colour; while pus forms a stratum at the bottom of water, is easily diffused by agitation to subside again in a short time, and is of a white or greenish-yellow colour, sometimes tinged with blood.

Our attention is now directed to ascertain whether there is any *sugar* in the urine. Many different methods have been proposed for the detection of this substance; but the most unfailing, so far as relates to chemical tests, is the one recommended by Trommer. It is founded on the fact, that a fluid containing sugar has the property of changing the colour of the sub-oxide of copper from a black to a red or brown. It is applied as follows: a few drops of a solution of sulphate of copper are added to a small quantity of the suspected urine, and afterwards an excess of liquor potassæ; on heating this the mixture becomes of a light or dark brown colour, in proportion to the amount of sugar present. This test is sometimes found to fail, for want of a few simple precautions. In the first place the liquor potassæ should be free from lead, which unites with any organic matter present to form a black compound, and it should therefore be kept in a green glass vial instead of a white one. Again, if ammonia be present it impairs the action of the test, and Trommer recommends that the urine be evaporated previously to testing it. But this is scarcely necessary. Cappezuoli advises the following mode, which will be found to answer perfectly, when it is not necessary that the result should be known immediately.

Add a solution of potash to that of sulphate of copper in a test-tube, wash the blue precipitate with water, add it to the suspected liquid, and then enough potash to render the mixture distinctly alkaline. Set the whole aside in a tall glass vessel, no heat being applied. At the end of a few hours, if sugar be present the blue precipitate is changed in colour, at first upon its surface, and finally throughout the whole mass, assuming a canary-yellow tint; and this is succeeded in a short time by a red one, the protoxide of copper being reduced. In making use of this test, which we have never known to fail however minute the quantity of sugar may be, it will be well that the same amount of sulphate of copper and liquor potassæ should be used in each instance. In this way the results obtained are always relative to one another, and we have in the changes produced by their addition, a standard of comparison. Moreover, if to a small quantity of urine a large proportion of each of these agents be added, the gelatinous mass formed by their reaction on one another, and which consists of undissolved hydrated oxide of copper, prevents the yellow tint from being equally disseminated throughout the tube. To prevent this, to about half an ounce of urine six drops of a saturated solution of sulphate of copper, and one drachm of liquor potassæ should be added, a proportion we have been in the habit of employing for this purpose.

A second test is that proposed by Moore, who recommends to boil the suspected urine in a test-tube with an excess of liquor potassæ, when if it contains sugar, the mixture will assume an orange-yellow, or brown, or claret

colour, in proportion to the quantity present, owing to the conversion of the diabetic saccharine matter into melassic acid.*

Biot states that of the different modes of diagnosing diabetic urine, the most certain results are to be obtained by the use of milk of lime. He directs a small quantity to be added to a specimen of urine, and the mixture boiled for a few minutes, when a distinctly-marked orange colour will be observed if sugar is present.

A third mode, for the detection of sugar, is to add a small quantity of yeast, which gives rise to the vinous fermentation, with the escape of carbonic acid in the proportion of about one cubic inch of gas to each grain of sugar present.

The action of saccharine urine on polarized light, as proposed by Biot and applied by Bouchardat, is said to

* This test is exceedingly marked, but in one instance that fell under our notice the same result occurred, although no sugar was present. We are not aware that any similar case has been spoken of. To the urine of a patient labouring under anæmia, to whom we were administering the muriated tincture of iron, we added a small quantity of liquor potassæ. Immediately the mixture changed from a light-yellow to a dark-claret colour, which became more marked on boiling, and in a few hours separated as a black, amorphous deposit. The same result, although to a less degree, took place on the addition of strong ammonia. To this deposit was added a few drops of nitro-muriatic acid, and the whole evaporated, then dissolved in distilled water, and filtered. On adding a small quantity of the yellow prussiate of potash in solution, the deep blue colour characteristic of the presence of iron was immediately perceived. This is the only instance in which we ever succeeded in detecting iron in the urinary secretion.

give more certain results than any mode yet used. But it is needless for us to enter into a description of this instrument, for we have never known with proper precautions, the test proposed by Trommer to fail.

If any moderate amount of sugar be present, the physical characters alone of the urine will often be sufficient for its detection. The taste and smell are generally sweet, resembling diluted syrup; the colour is a faint amber, inclining to green, and often the consistency of the fluid is increased. The specific gravity is always high, much above the usual standard, and this is coincident with the discharge of an increased quantity. In addition to these characteristics, we find all the other solid ingredients very deficient, particularly the urea and uric acid.

The detection of *Oxalate of Lime*, perhaps the most important of all the abnormal elements which are found in the urine, is at the same time the most difficult without the aid of a microscope. It never exists in a state of solution, and, from its property of refracting light to nearly the same degree as urine, cannot be seen when it is everywhere equally disseminated through it, unless it exist in very large quantities. Bird recommends when its presence is suspected, to set aside a specimen of the secretion in a tall glass vessel, and allow it to stand for a few hours. Then carefully to decant all but the lowermost stratum, which is to be poured into a watch-glass. This is gently heated to dissolve the urate of ammonia if any be present, at the same time gently performing a rotary motion, by which the crystals are collected at the bottom of

the glass. All the supernatant fluid is then removed by means of a pipette, and its place supplied with distilled water or alcohol, when a shining powder will make its appearance. This we recognise to be oxalate of lime by its ready solubility in dilute nitric acid without any indication being afforded of the presence of lithic acid; by its becoming white on incineration from being changed into carbonate of lime, which is dissolved by nitric acid with effervescence, and by its insolubility when boiled in liquor potassæ or acetic acid.

The physical characters of the urine afford very little assistance in the detection of this salt; the colour and the specific gravity, in the average of a large number of cases, are found to vary very little from the normal standard. Most specimens of urine in which oxalate of lime is to be observed, contain epithelium scales, and these alone, in undue proportion, should always make us suspect the existence of this salt.

Another substance found occasionally, though very rarely, in urine is *Cystin*. We ourselves, have seen it in but one or two instances, and as Golding Bird has given the best description of its mode of detection, we transfer it from his work. Cystin "forms a nearly white, or pale fawn-coloured pulverulent deposit, much resembling urate of ammonia. It is never found in solution, the urine containing it being always turbid at the moment of emission, and it very soon deposits a copious sediment. Heat produces no change, and it very slowly dissolves on the subsequent addition of hydrochloric or nitric acids. It is

readily soluble in ammonia and the fixed alkalies and their carbonates, but is insoluble in carbonate of ammonia. Heated upon platinum foil it burns, evolving a peculiar and disagreeable odour. It may be distinguished from urate of ammonia by being unchanged on the addition of heat; and from the phosphates by being insoluble in dilute hydrochloric, or nitric, or strong acetic acid," at the same time that it is perfectly soluble in ammonia. Cystin contains a large proportion of sulphur, and Liebig has proposed to detect it by means of an alkaline solution of lead, when a black precipitate, the sulphuret of lead, would be formed. But this test is very fallacious, for if albumen or any other animal matter containing sulphur were present, the same result would follow. The odour of the urine in some of these cases is very characteristic, resembling, to a remarkable degree, that of sweetbrier.

Bile is occasionally present in the secretion under consideration, and may be recognised by the following peculiarities. Its colouring matter is insoluble in water, but soluble in caustic potash; the addition of water therefore, produces no change, but the other immediately renders the urine almost transparent, if its dark colour be owing to the presence of bile. Urine containing it, assumes a greenish tinge on the addition of muriatic and sulphuric acids; and nitric acid also produces a greenish tinge at first, but it soon changes to a red, violet, or pink colour. This greenish hue is produced by the colouring matter of the bile absorbing oxygen; and nitric acid effects it by supplying this gas.

Kyestein. Some years ago Nauche announced the discovery of a peculiar substance to be found in the urine of pregnant women, to which he gave the name of Kyestein. Its pathology and importance, in a diagnostic point of view, we will consider hereafter. Dr. Kane, who has made the most extensive observations on this substance, states that it never makes its appearance before thirty hours, or later than eight days, and in most cases is first observed on the third day. He also ascertained that it was present not only in women who were pregnant, but also in those who were suckling, in cases where the secretion was from any cause checked. It has the appearance of a cotton-like cloud at first, which soon changes into a number of minute opaque bodies, which rise to the surface and form a fatty pellicle. This pellicle, when held in a strong light, has often a glittering appearance from the presence of the triple phosphate. After remaining for three or four days the urine gradually becomes turbid, small flocculi fall off from the crust and sink to the bottom, and this goes on till the whole has disappeared. Pellicles are often observed to form on the surface of urine after standing for some days, under other conditions than those above mentioned, but they may be distinguished from Kyestein by the latter never becoming mouldy, or remaining on the surface more than three or four days.

The preceding directions include all that can be said, in the limits to which we have confined ourselves, in relation to the chemical examination of the urine. They indicate the mode of detecting nearly all the substances that are

interesting in a pathological point of view, and all from which we can derive therapeutical indications. It will be seen by reference to the chapter on the microscopic examination of the urine, that many of these substances can be more readily ascertained by its employment, than by the unaided assistance of chemical tests.

APPENDIX TO CHAPTER II.

MODE OF OBTAINING HIPPURIC ACID ACCORDING TO LIEBIG.

Fresh urine is evaporated in a water-bath to the consistence of a syrup; it is then mixed with some hydrochloric acid, and agitated with its own volume of ether, which latter substance dissolves the hippuric acid. It usually happens that the mixture does not separate spontaneously, but that the ether remains enclosed in the fluid like froth; the separation of the ether takes place immediately upon adding to the mixture, after having allowed it to stand at rest for an hour, one-twentieth part of its volume of alcohol. In this case the froth disappears, and the fluid separates into two layers. The upper layer contains the hippuric acid in solution; but it also contains urea, owing to the addition of the alcohol. This upper layer is carefully removed by means of a pipette or syphon, and agitated with small portions of water; the water removes the alcohol and urea, whilst the hippuric acid remains in solution in the ether. By evaporating the ethereal solution the hippuric acid is obtained in crystals. The crystals produced are usually of a yellowish or brown colour, arising

from the presence of a resinous substance, which may be easily and completely removed by means of animal charcoal.

TESTS FOR SUGAR.

Among the many different modes proposed for the detection of this substance in the urine are the two following. They were omitted in the text because both are liable to induce error.

Hünefeld's Test is performed by placing in a glass vessel exposed to the sun's rays about four ounces of the urine, to which is added five or six drops of a tolerably strong solution of chromic acid. In a few minutes if sugar is present, the mixture previously orange-red, becomes brownish, and soon after assumes a bistre-brown colour. This change takes place much more quickly if the mixture be gently warmed before exposing it to the light. It is produced by the deoxidizing power of the sugar upon the chromic acid, by which it is reduced to the oxide of chromium. The objection to it is a very serious one. All urine contains a certain amount of colouring matters, which have the same effect as sugar upon chromic acid, and it becomes deoxidized, although to a less degree.

Runge proposes the following. Allow a thin layer of the suspected urine to evaporate on a white surface, a plate for instance. And whilst warm, drop upon the surface a few drops of sulphuric acid diluted with six parts of water. In healthy urine the part touched with

the acid becomes merely of a pale yellow colour; but if sugar is present, the spot becomes deep brown, and then black, from the decomposition of the sugar by the acid, and consequent evolution of carbon. This test is a very delicate one, but is unfortunately fallacious, because albumen in urine undergoes the same change on the addition of sulphuric acid.

SULPHATE OF LIME IN EXCESS IN THE URINE.

All urine contains lime in an appreciable proportion; but it is always found in solution, unless existing as an oxalate. Its quantity is almost entirely dependent upon the quantity contained in different articles of diet, and we have occasionally seen it present in so large a proportion in individuals living in a limestone district, as to produce very unpleasant symptoms, particularly constant irritability of the bladder, with pain and smarting during the act of micturition. It is readily detected by adding a few drops of a solution of oxalic acid, when it is immediately deposited as the insoluble oxalate of lime. In the instances just mentioned the lime was combined with sulphuric acid in the form of sulphate of lime. This acid is readily detected in the urine by adding a solution of the nitrate or muriate of barytes. The latter is the preferable from its greater solubility. A white precipitate is formed, consisting either of the carbonate or the sulphate of barytes, or both. This precipitate is collected by gravitation, and a few drops of sulphuric acid added. If it consists of

carbonate of barytes, effervescence ensues with the liberation of carbonic acid, but if no change takes place it exists in the form of a sulphate.

QUANTITATIVE ANALYSES OF HEALTHY URINE.

According to Berzelius.		Average of three Analyses by Lehmann.	
Water, ...	933·00	Water, ...	934·567
Urea, ...	30·10	Urea, ...	32·424
Uric Acid, ...	1·00	Uric Acid, ...	1·064
*Lactic Acid, Lactates, and Animal Matter, . . .	17·14	Lactic Acid,*	1·520
		Lactates, ...	1·565
Mucus of the bladder, .	0·32	Mucus, ...	0·107
Sulphate of Potash, . .	3·71	Alkaline Sulphates, . .	7·308
Sulphate of Soda, . . .	3·16	Phosphate of Soda, . .	3·806
Phosphate of Soda, . . .	2·94	Phosphates of Lime and Magnesia, ...	1·142
Phosphate of Ammonia, .	1·65	Chlorides of Soda and Ammonia, ...	3·653
Chloride of Sodium, . .	4·45	Water extract, . . .	0·614
Hydrochlorate of Ammonia,	1·50	Spirit and Alcohol Extract,	10·267
Earthy Matters, with a trace of Fluoride of Calcium,	1·00		
Silicious Earth, ...	0·03		
	1000·00		

In neither of these analyses has any attention been paid to the hippuric acid, which is always present in about the same proportion as uric acid, and it will also be seen that

* According to more recent observations there is no lactic acid in urine, and Liebig thinks the extractive matters, which he terms kreatine and kreatinine, were mistaken for it. These latter contain nitrogen.

Berzelius has omitted to detect any magnesia, a substance which is rarely if ever absent from healthy urine.

DR. HENRY'S TABLE SHOWING THE QUANTITY OF SOLID MATTER IN URINE OF DIFFERENT DENSITIES.

Specific gravity of the urine, water being 1000.	Quantity of solid matters in a wine pint in grains.
1020	382·4
1021	401·6
1022	420·8
1023	440·0
1024	459·2
1025	478·4
1026	497·6
1027	516·8
1028	536·0
1029	555·2
1030	574·4
1031	593·6
1032	612·8
1033	632·0
1034	651·2
1035	670·4
1036	689·6
1037	708·8
1038	728·0
1039	747·2
1040	766·4
1042	804·8
1044	843·2
1046	881·6
1048	920·0
1050	958·4

LIEBIG'S MODE OF DETECTING KREATINE AND KREATININE.*

The urine is first neutralized by milk of lime, and then a solution of chloride of calcium is added as long as it causes a precipitate of phosphate of lime. The liquid is then filtered, and evaporated till the salts crystallize out on cooling. The mother liquor is separated without the use of alcohol, from the salts, and mixed with a syrupy solution of neutral chloride of zinc in the proportion of about half an ounce to one pound of the extract.

After three or four days, the greater part of the zinc compound is found to have crystallized in rounded yellow grains. This deposit is well washed with cold water, then dissolved in boiling water, and hydrated oxide of lead added to the solution till it acquires a strong alkaline reaction. By this means the zinc and hydrochloric acid are separated in an insoluble form, while the substance formerly combined with them, remains in solution. This is now acted on with blood charcoal, which removes a yellow colouring matter and a trace of oxide of lead, and the filtered liquid is evaporated to dryness.

By this process there is obtained a white crystalline substance, which closer investigation shows to be a mixture of two compounds of different properties, which may easily be separated by means of alcohol, one of them being easily the other very sparingly soluble in alcohol. When a portion of the mixed substance is boiled with eight or ten

* Chemistry of the Food, page 51.

times its weight of alcohol, either a part remains undissolved, or the solution is complete but deposits crystals on cooling. These crystals are found to be identical with the undissolved residue. When they are separated from the mother liquor, and the latter evaporated, a new crystallization of different form and properties is obtained. The body which crystallized first or remains in the undissolved residue, contains water of crystallization and has no action on vegetable colours; the more soluble has in its aqueous solution a strong alkaline reaction, and its crystals do not effloresce when heated. The one that first crystallizes during this process is kreatine, the other kreatinine.

CHAPTER III.

ON THE MICROSCOPIC EXAMINATION OF THE URINE.

We have already stated in the preceding chapters that, with the exception of sugar and albumen, so long as the different ingredients of the urinary secretion remain in a state of solution, their importance in a therapeutical point of view is not very great, except as indicative of the particular diathesis under which the patient is suffering; and that in a majority of instances, an examination of the sediment alone will afford all the information necessary for practical purposes. This knowledge may be obtained nearly always by chemical analysis, according to the directions previously given, but it will be seen in the present chapter that by the use of the microscope, the same results may be arrived at with much more certainty, and with a less expenditure of time; that many substances, whose detection by means of chemical tests when in large quantities is very simple, is nevertheless impossible without the aid of this instrument when a few crystals only are present; and moreover, that where more than one substance exists as a deposit, an estimation of their relative

proportions is exceedingly difficult without the aid of a microscopic examination.

Before entering into a detailed description of the appearance that these different substances present, it will be well for us to give some simple directions as to the use of the instrument, and the proper selection of the urine for examination. A microscope with a power of two hundred and fifty diameters is the one we have usually employed, and this will be sufficient for all the purposes of urinary examination. With a less power, crystals of oxalate of lime, whose sides are sometimes even smaller than the $\frac{1}{5000}$ of an inch, cannot be observed with sufficient distinctness to decide upon their shape; and the more complicated arrangements belonging to an instrument of higher power render its practical application somewhat difficult to one unaccustomed to its use; besides, in many cases, rendering the size of the object greater at the expense of its distinctness. It must be remembered, however, that for the present purpose the value of a microscope does not consist so much in its magnifying power as its distinctness, and that in all cases an instrument is to be preferred whose mode of adjustment is simple, and whose power is of a medium range.

The urine is selected as follows:—it is obtained, as for the previous examinations, either at separate periods, or an average specimen of the whole passed in twenty-four hours, is taken. And as nearly all the undissolved substances in the secretion after a few hours gravitate to the bottom of the vessel, to obtain a specimen of the lowermost

stratum we should allow the urine to stand for a few hours, then decant the upper five-sixths, and pour the remainder into a long and narrow test-glass. Here again, by gravitation, the substances will collect in larger quantity at the bottom of the glass, and on pouring off all but the lowermost stratum, we will have a greater number of crystals collected in a single drop than if it were selected indiscriminately. We have frequently observed a specimen of urine apparently clear, and in a drop of whose upper surface nothing could be discovered under the field of the microscope, present a considerable quantity of crystals after observing these precautions. There is one exception, however, to this in the crystals of oxalate of lime. These possess nearly the same specific gravity as the urine itself, and as a general rule will be found equally disseminated throughout the specimen, so that a drop of its upper surface will oftentimes present as numerous an array of crystals as that taken from any other portion. A single drop is amply sufficient for the detection of any substances present, and instead of pouring it into the hollowed glass provided with the instrument for the examination of fluids, it will be better to place it between two clear flat pieces of glass, and then subject it to the microscope. Putting the two pieces of glass together requires some little tact to prevent the formation of air-bubbles, which interfere with the exact sight of the object under examination. We should also mention that we have found the light of an ordinary study lamp far preferable to that obtained from the sun in the use of the microscope: it is more concentrated and there is less glare.

It is often difficult, when a specimen of urine has to be sent from some distance, to make an exact examination of it. The time that must elapse before it can be received allows certain changes to take place, and crystals to make their appearance which did not exist at the time the specimen was voided. One of our friends has been in the habit for some time of desiring his patients when thus removed, to filter their urine soon after emission, through a filter paper which he transmits to them in a letter envelope. This is dried and returned, and on moistening a portion of the sediment thus obtained with a drop of water, the substances may be observed under the microscope some days afterwards as they existed at the time the urine was passed. Even pus globules may be thus detected.

We will now detail the different appearances that these substances present under the field of the microscope.

Uric Acid.—There is no crystalline deposit which presents under the microscope such an endless variety of forms as this. When found in urine, however, they have all one recognisable characteristic in their colour, which is usually some shade of orange or yellow, and this varies from the deepest orange to the lightest yellow. These crystals soon undergo a change by uniting with the ammonia liberated by decomposition, and have a tendency to become amorphous, so that occurring naturally as a deposit, they are rarely distinctly crystalline if retained for any length of time in the bladder or kidneys. When deposited either by the addition of acid or otherwise, the crystals are either separate or collected into clusters, and whatever

be their shape they may all be referred to some modification of the rhombus, square or rectangle. The most common form in which they are usually observed, is as a simple rhomb, square or rectangle, with a thickness equal to about one-fourth its length (fig. 1, 1, 2, 3, 4). It is often

Fig. 1.

DIFFERENT FORMS OF URIC ACID.

1. Rectangular forms of uric acid. These are often flattened cylinders, and viewed in a plane at right angles to this, present the appearance of 4, and 5.
2. These may be cubes, or have at right angles a similar section to the above.
3. A modification of the preceding.
4. The rhomboid form. These are generally flat.
5. This form is only deposited from very acid urine. The edges have a serrated appearance.
6. Same as above. But its surface is crossed by two crescentic borders.
7. A very common form. A white space in the centre, and the ends having the appearance of projecting from it. These by time break up and become amorphous, at first along the edges, then in the body of the crystal.
8. This figure has an elevated ridge in the centre, and its section resembles somewhat fig. 2, 4.
9. This variety is nearly amorphous, and is rarely seen but in those specimens which have undergone decomposition.
10. This form is rare. Its section is rectangular.
11. Resembles somewhat the stellæ of the triple phosphate. But it is made up of rectangles. This variety is very rare, and we have copied it from Griffith.
12. A number of rectangular crystals of uric acid grouped together to form a single one, having somewhat the appearance of a sheaf of wheat.

difficult to appreciate the thickness of these crystals, from the fact of the microscope only presenting the view of a single face, but this may be remedied by adding a drop of ether or alcohol, which by evaporation, produces currents in different directions, so that the crystals are turned from side to side, and allow an accurate observation of each face ; in this way figures presenting a different appearance are often found to belong to the same crystal.

The next most common form uric acid presents, is that of a rhomb, with the sides curved outwardly. These are flat plates, of a faint yellow colour (fig. 2, 4). Occasionally they are modified so as to resemble that figure which would be included between the segments of two equal circles (fig. 1, 8); and which in reality is nothing more than the previous rhomb, with the two obtuse angles rounded off. In a majority of cases this is the same crystal as those figured (fig. 1, 1), the view being in a plane at right angles to the preceding. The thickness of this form varies from one-eighth to double its length, and as a general rule the smaller the crystal the greater its thickness, and vice versa. These last are also occasionally modified by a rounding off at the ends and a bulging out at the sides, so as to give them somewhat the appearance of spindles (fig. 1, 10).

Another quite common variety, forming in themselves a distinct group, is where the ends of the crystal have a serrated appearance. These may either seem to be made up of long needles, placed side by side, or have an apex in the centre, the two long sides of the pyramid thus formed

being strongly shaded. Fig. 1, (5.) If simply composed of needles, the striated appearance is variously modified. In the middle of some it is often entirely lost, and the surface being nearly smooth and squared off, the needles have the appearance of projecting from a rectangular surface. Fig. 1, (7.) Occasionally it is marked across by two crescents, placed with their convexities opposed. Fig. 1, (6.)

Fig. 2.

DIFFERENT FORMS OF URIC ACID.

1. If a number of crystals of uric acid are allowed to remain undisturbed for some time, aggregation will take place, and figures resembling this which is copied from the field of the microscope will often present themselves.

2. Is an amorphous crystal of uric acid, very commonly observed in urine voided some time previous to examination.

3. Another variety, usually observed some days after emission.

4. These crystals are either found in thin plates, or are sections of the rectangular figures above mentioned.

5. Is a section of the rectangular figures.

6 and 7. These crystals were deposited from a specimen of healthy urine, on the addition of muriatic acid. The individual was apparently in good health. Their colour was a very faint yellow.

All these crystals of uric acid, except Fig. 1, (11,) are of a yellow or orange-yellow colour. Fig. 2, (1, 2, 3,) present the deepest shade.

These projections again are not always of a uniform length, in some specimens increasing from each side towards the centre in steps, as it were, until at last they terminate in a kind of point. Fig. 1, (7.)

Another variety very commonly found, particularly in a deposit allowed to stand for a short time, retains the striated appearance, but is no longer serrated at the edges, and the crystals are more amorphous in shape. Fig. 1, (9.) Fig. 2, (3,) represents a variety of uric acid somewhat similar to the above, and quite commonly met with if allowed to form very slowly. Its surface is striated in irregular short curves, each series of which seems to be elevated above the preceding.

Others again present a stellated appearance, being made up of large rectangular crystals, either laid across one another, or radiating from a common centre. This variety is very rare, and is the only specimen of uric acid that we have ever observed to be perfectly colourless. Fig. 1, (2.) As a modification of this form, we may sometimes observe these long rectangular crystals lying irregularly side by side, with one or two additional ones crossing them in the centre at right angles, so that the whole figure is easily fancied to resemble a sheaf of grain. Fig. 1, (12.)

If a deposit of uric acid be examined after the lapse of a few days, many of the crystals will have undergone more or less change. Some present an entirely amorphous appearance, and are only recognisable by their colour. Fig. 2, (2.) Others again by aggregation form large crystalline masses without any definite form, and sufficiently large to

occupy nearly the whole field of observation. One of these we have copied. Fig. 2, (1.)

We have frequently observed in specimens of urine, after the addition of muriatic acid, flat round or rounded bodies of a faint yellow colour, Fig. 2, (6,) which dissolved on the addition of a drop of liquor potassæ, and were in other respects similar to uric acid. Their surfaces are crossed irregularly by fine lines, and occasionally these lines radiate from a common centre. Fig. 2, (7.) The urine from which the figures in the plate corresponding to the above description were taken was perfectly healthy, but most frequently we have observed them deposited by acid in those specimens that exhibited under the microscope oxalate of lime, and we rather incline to the opinion that they are some intermediate stage between this salt and uric acid.

As a general rule, the colour alone of uric acid crystals is entirely sufficient for their recognition. The different shapes that they assume, although not entirely accounted for, appear to be influenced principally by the nature of the precipitating agent, the greater or less rapidity of crystallization, and the degree of disintegration that has taken place. The quadrilateral figures which are serrated at their extremities and marked by dark lines on their surfaces, are usually found in very acid urine, and have been observed by us to occur much more frequently in summer than in winter. The divergence of this same form towards a point at the end, seems to be owing to a portion of the crystal which was originally square falling off, and we have only noticed them in specimens of urine which

had been standing for some days, and where the crystals had begun to undergo decomposition.

Urate of Ammonia occurs most commonly in small, minute, transparent and amorphous grains, generally clustered together, but at times separate. Fig. 3, (1.) Occasionally

Fig. 3.

URATE OF AMMONIA, URATE OF SODA, CHLORIDE OF SODIUM, AND CYSTIN.

1. Represents the ordinary appearance of urate of ammonia.
2. The same, but less frequently observed.
3. The same. The projecting points are most probably uric acid. This variety is very infrequent.
4. A rare form of urate of soda, after Griffith.
5. The most usual form of urate of soda, as it occurs in urinary deposits.
6. Chloride of sodium, as it crystallizes from distilled water. In many respects it resembles the octohedra of oxalate of lime, but the lines are less sharp, they are only found when no fluid is present, and never exist in urine.
7. The same, slowly crystallized from urine. Still somewhat like oxalate of lime, but never found when any fluid is present.
8. Chloride of sodium, in combination with urea, and evaporated quickly from urine. These figures are a certain indication of the presence of urea. They are here represented one-third their usual size.
9. Cystin, after Golding Bird. This appearance it presents, when existing as a deposit.
10. The same, after being slowly evaporated from their solution in ammonia.
11. Urate of soda, formed by dissolving uric acid in a hot solution of carbonate of soda.
12. Urate of soda. After Golding Bird.

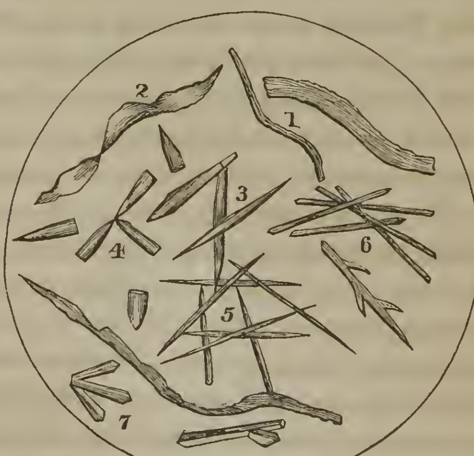
mixed with these there may be observed larger rounded globules, sometimes united two and two. Fig. 3, (2.) When uric acid and urate of ammonia exist together, the globules often present the appearance of being studded around with sharp and elongated points, these being probably the projections of the uric acid. Fig. 3, (3.) The small amorphous variety of urate of ammonia may be readily mistaken for one form of phosphate of lime, but the latter is only found in neutral or alkaline urine, and dissolves immediately on the addition of a drop of hydrochloric acid, while the other is dissolved but slowly, and is replaced after a short time by small lozenge-shaped crystals of uric acid.

Urate of Soda presents itself under two or three different forms. The most common is that of globules, with rectangular or prismatic projections arranged in stellar groups. Fig. 3, (4.) This form is liable to be confounded with one variety of urate of ammonia with uric acid intermixed, but Griffith states that they may be distinguished by the needles of the latter being acute at their extremities, while in the former they are always obtuse. When artificially prepared by dissolving uric acid in carbonate of soda, they crystallize in tufts which bear a great resemblance to the tufts of margarine obtained from human fat. Fig. 3, (11.) Golding Bird describes a third form, in which the processes are generally curved, and have somewhat the appearance of the claws of an insect, Fig. 3, (12,) but this variety we have never seen.

Hippuric Acid when perfectly pure, presents itself in

long, shining, transparent figures, modified in various ways; but as it never exists in the urine as a deposit, but must always be thrown down by some other acid, it is rarely found in transparent crystals, and we have always observed it of nearly the same colour as uric acid. Most of these crystals, unless made to revolve, have the appearance under the microscope of long flat rectangles, and have a tendency after a time to arrange themselves side by side, and present somewhat the appearance of one of the forms of uric acid spoken of above. By aggregation, these sometimes become so large, that a single one is sufficient to fill up the whole field of the microscope, even when a low power is used.

Fig. 4.



HIPPURIC ACID.

1, 2. The ordinary forms that hippuric acid presents when examined in the urine of an individual during the administration of benzoic acid.
3, 4, 5, 6, 7. Different forms from the urine of a healthy individual.

If from the urine of an individual to whom large quantities of benzoic acid have been administered, the hippuric acid be obtained by the mode previously mentioned, the figures are almost always more or less curved, and present but little traces of crystalline arrangement. Some have the appearance of long, slender, flattened bodies, the sides varying to a greater or less degree from a right line, and in length, from the eightieth to the one hundredth of an inch, Fig. 4, (1,) and at times they are so irregular as to be twisted spirally on themselves for three or even four turns. Fig. 4, (2.)

When deposited from urine under ordinary circumstances, their axes are always in straight lines. Some are very short, shaded at the sides, square at one extremity, and diverging to a point at the other. Fig. 4, (4.) Others are much longer, and diverge at both ends. The breadth of these latter is very variable; some specimens being as long and slender as a fine sewing needle. Fig. 4, (5.) At times the deposit is made up of long, shining, transparent, four-sided, obliquely truncated prisms Fig. 4, (6); while in other specimens the prisms are broader, and three or more are united at one end, and have the appearance of radiating from a common centre. Fig. 4, (7.)

The Phosphate of Magnesia and Ammonia is always deposited in transparent and colourless crystals, and assumes very different forms, dependent upon the rapidity with which crystallization takes place. This difference has been heretofore explained by supposing that they were two separate salts, one monobasic, the other deutobasic, the

latter containing twice as much ammonia as the former. But this we think is not the case; for if certain precautions be used in the formation of this salt, it may be shown that the difference is entirely due to the rapidity with which crystallization takes place, the stellar variety being first deposited, and the prisms subsequently formed by the aggregation around these of crystalline material. This change has been more fully entered into at another place, and Fig. 10 exhibits the mode in which it takes place. In the urine, however, we have never seen both these forms existing at the same time, nor have we ever observed the stellar variety to be formed spontaneously, although Golding Bird has remarked it in some few specimens.

The prismatic triple phosphate is found in both acid and alkaline urine, and is by far the most beautiful microscopic object presented in urinary deposits. Its primitive form is that of a prism, Fig. 5, (1); but after a short time its angles become replaced by facets, so that it presents in some instances an exceedingly compound appearance, but still referable to the same original prism. Fig. 5, (4.) A quite common form is where the upper portion of the crystal presents a smooth rectilinear surface parallel to the square or rectangle which composes the base, Fig. 5, (2); but it is not at all necessary that the base should consist of four sides only. The angles of some are squared off in such a manner that an eight-sided figure results, Fig. 5, (3,) and others again are even more complicated than this. All these modifications are found collected together, and composing the same deposit. These crystals are at times so

large, particularly when they have formed slowly, that two or three are sufficient to fill the whole field of the microscope.

The other variety of the triple phosphate is composed of elegant stellæ, very variable in size; the perfect crystals

Fig. 5.

TRIPLE PHOSPHATE, AND PHOSPHATE OF LIME.

1, 2. Represent the most perfect crystals of the prismatic variety of the triple phosphate.
3. Is a slight modification of the preceding.
4. Exhibits a more compound arrangement, still referable to the same form.
These different varieties are all found in the same specimen.
5. The most perfect varieties of the stellæ. More commonly the greater part of the deposit consists of less perfect crystals than these, and we have never seen them thus perfectly formed without the artificial addition of ammonia.
6. These foliaceous crystals are usually found when precipitated from very acid urine. They are more rare than the preceding; and both of these forms are observed occasionally to be tinted with pink and green colours.
7, 8. Are other varieties of the same; very rare.
9. Phosphate of lime. This salt is never observed in a crystalline form. It is either an amorphous powder, or collected in rounded particles similar to the plate, mixed with the triple phosphate.
10. These bodies are represented by Simon, as having occurred in a deposit of phosphate of lime; but they are in all probability, as he states, some form of urate.

usually having six projecting rays, Fig. 5, (5) but sometimes only four. These rays are more or less serrated along the edges, and owing apparently to accidental circumstances, the crystals assume a variety of appearances, all referable to the same stellar form.

The penniform crystals of this salt, Fig. 5, (6,) are not so commonly observed as the others. They are joined together, either at one end, so as to present the appearance of radiating from a common centre, or are in a continuous line; but at times they are entirely separate. These crystals are all very transparent, and require a strong light to distinguish their outline clearly. Occasionally they are observed to be tinted with various hues, in which pink and green predominate. The crystals of this form of triple phosphate, as observed under the microscope, do not usually present the perfect forms we have just been describing. More commonly there are portions only of the crystal distributed irregularly throughout the field, which becoming agglomerated after a time, unite to form an entire stella. This salt when deposited from urine by the addition of ammonia, is found associated with numerous amorphous bodies, the phosphate of lime, which will be described directly.

Phosphate of Lime always occurs in small, rounded, amorphous particles, often scarcely distinguishable from one of the varieties of urate of ammonia, Fig. 5, (9); after standing for some time we may occasionally observe foliaceous bodies having more or less of a crystalline appearance, which have been described as phosphate of lime.

Simon gives a representation of these, Fig. 5, (10); but they are in all probability some one of the forms of the urates.

Chloride of Sodium is perfectly soluble in both water and urine, but on evaporation assumes certain figures which might be mistaken for either cystin or oxalate of lime, except that the latter are in solution. When this salt is dissolved in distilled water, and the solution allowed to crystallize by evaporation, it presents the appearance of octohedra, which resemble, in some respects, oxalate of lime, Fig. 3, (6); but if evaporated slowly from urine it unites with urea, and forms irregular six-sided figures, which might be mistaken for cystin. Fig. 3, (7.) When the evaporation is conducted more slowly, these transparent lamina are replaced by a series of figures shaped like crosslets and daggers. Fig. 3, (8.) The diagnosis, however, is very easily made. Chloride of sodium being perfectly soluble is never found in a crystalline form when any fluid is present, and if the suspected crystals appear after evaporation, we have but to add a drop of water, when chloride of sodium is immediately dissolved, while oxalate of lime or cystin remain unchanged. The appearance of the latter form, that is the crosslets, may always be taken as an indication of the presence of urea.

Cystin when deposited from urine is always crystalline, and generally presents itself under the microscope in the form of round, flat plates, with irregular crenated edges. Fig. 3, (9.) Towards the centre of these plates there is a circular opacity, apparently made up by the aggregation

of small, amorphous bodies, and at the same time, there is a circle of transparency near the circumference. According to Simon, this crenated margin which gives these crystals the appearance of rosettes, is due to a number of hexagonal plates to be described presently, placed one on the other, and there is generally to be observed at the same time, a few of these six-sided crystals interspersed among the others.

When a deposit of cystin is dissolved in ammonia, and the solution allowed to evaporate spontaneously, it crystallizes in the form of six-sided plates, which Golding Bird thinks are exceedingly short, hexagonal prisms. Fig. 3, (10.) These figures are generally transparent, but occasionally their surfaces are crossed by irregular lines, and bounded at their circumferences by a thick, irregular, and opaque margin. At times, particularly under a strong light, some of these crystals present a beautiful series of bright colours, which are the more marked in contrast to their dark, opaque borders. Griffith describes them occasionally as occurring in the form of long, flat rectangles, but this variety is not mentioned by other observers.

Oxalate of Lime.—No urinary deposit, not even uric acid, presents under the microscope such a variety of forms as oxalate of lime. We are unable from our present knowledge, to state with certainty upon what this variety of form is dependent, but will endeavour to show that, as in the case of uric acid, many different appearances are to be explained by the views being in planes at right angles to one another. The double octohedra are

by far the most common variety, and after these the dumb bells. But we have not found these last evidencing a severer form of disease, as has been heretofore stated, nor have we as a general rule remarked that they usually became replaced by the ordinary octohedral crystals before convalescence was entirely established.

When oxalic acid is added to urine, or any fluid containing lime, the oxalate of lime formed under these circumstances, as observed under the microscope, consists of small, rounded masses, without any definite crystalline form, and, on boiling the fluid in which they are contained, minute octohedra become perceptible. When formed, however, in the urine, owing to the mode in which ammonia is liberated, they are found much larger, and of a great variety of shapes, all of which are more or less crystalline. As stated above, by far the most common of these varieties is the octohedron, or double pyramid. At first sight these almost always resemble squares, marked across their surfaces by two diagonal lines, but closer observation shows the point where the diagonals cross one another to be the apex of a pyramid with a square base, and usually bevelled along the edges. On adding ether or alcohol so as to produce currents in different directions by evaporation, these crystals may plainly be seen to be double pyramids, each with a height equal to the length of its base. Fig. 6, (1.) Wollaston and others state that the octohedron is most frequently flattened, but this is merely owing to the particular plane in which it is seen. Fig. 6, (2.) Their size is extremely variable; we have noticed crystals as small as

the amorphous masses of urate of ammonia and scarcely more distinguishable, and again others with an apparent base of nearly three-quarters of an inch in length. Golding Bird gives $\frac{1}{750}$ and $\frac{1}{5600}$ of an inch as the extreme

Fig. 6.

OXALATE OF LIME.

1. The most common form of oxalate of lime. The sides of these vary from 1-5600 to 1-500 of an inch in length.
2. Same as preceding, viewed in a different plane.
3. Larger forms of the same. In all the large crystals of this salt the sides are observed to be bevelled.
4. Represents the oxalate as it appears when dried on glass. But this appearance is rare. It is necessary that the crystals should be very large, and we do not always then succeed in detecting them in this form.

5 and 6. Are the oval figures that this salt sometimes presents. They vary very much in size, and are the next most common form to the dumb bells.

7. Similar to the preceding, with the exception of the elevated ridge and the bevelled extremities.
8. Ovals, with dumb bells enclosed. These are usually found mixed with the preceding, and are, in all probability, an intermediate stage of the change from ovals into dumb bells spoken of in the text.
9. Dumb bells. These, although included under the head of oxalate of lime, are in reality formed by the disintegration of uric acid, and there is no lime entering into their composition. In many cases also when observed at right angles to the present view, they are ovals similar to 5 and 6.
10. Dumb bells as usually observed when found with the ovals.
11. More irregular forms of the dumb bell crystals.

measurements of some of his specimens; but supposing the side of the largest observed by us to be one-half an inch in length under a microscope magnifying two hundred and fifty diameters, its real length would be as much as $\frac{1}{500}$ of an inch.

If this salt be allowed to dry on a plate of glass and then examined, each crystal resembles two superimposed, concentric cubes with their angles and sides opposed, the outer black, and the inner transparent, Fig. 6, (4,) but this appearance is lost unless the crystals be large, and a low magnifying power used. This is explained by Griffith as being due to the lateral rays being refracted beyond or without the field of the microscope. These octohedral crystals are not always of one uniform size in the same specimen, and often vary from day to day in the same individual.

The next most frequent variety observed is the dumb bell, in length from $\frac{1}{600}$ to $\frac{1}{1500}$ of an inch. Fig. 6, (9.) The degree of indentation of the sides of these is extremely variable, the figures being sometimes nearly oval, and at others so much depressed as to resemble two kidney beans placed opposite one another, and connected in the middle. Their surfaces are more or less opaque, and at times are crossed by curved lines in the direction of their length. Occasionally as a modification of this form, the dumb bells are surrounded by an oval, the interval between the two being of a black colour. Fig. 6, (8.) These two appearances belong in reality to the same figure viewed in planes at right angles to one another, and although included here under the

head of oxalate of lime, we will show at another place that their peculiar shape is in all probability, entirely due to the disintegration of uric acid. (See Figure 7.)

Fig. 7.

CHANGE FROM URIC ACID INTO DUMB BELLS.

1. Crystals of uric acid in the act of breaking in half by disintegration.
2. Two perfect crystals of uric acid united at one extremity preparatory to the others falling off.
3. Same as preceding, except one end has become one of the balls of the dumb bell.
4. These are irregularly-formed dumb bells, found in another specimen of uric acid allowed to stand for a few days.
5. Crystals of uric acid just commencing to disintegrate.
6. Fully-formed dumb bells.
7. Dumb bells formed from ovals.

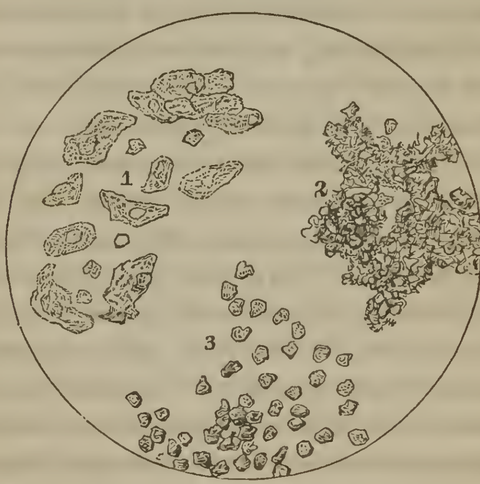
We have also observed some crystals of this salt having the appearance of dark ovals of the same size as the preceding, with a transparent square, occupying half its surface, set in the middle. Fig. 6, (5.) Again, this latter form is sometimes modified by the oval appearing as though an

elevated ridge ran through the centre parallel to its long diameter, while the two ends are bevelled off by facets running in an oblique and opposite direction. Fig. 6, (7.) Still another form which we have observed but rarely, is two concentric ovals of different diameters set one within the other, the interval between the two being transparent, and upon the innermost, facets rising upwards in a pyramidal point at the centre. Figures somewhat similar to these are included in Simon's plates under the head of uric acid. We have not seen a sufficient number of these dumb bells and oval forms of oxalate of lime to speak with certainty in regard to their comparative frequency, but will refer to this point at another place. In all cases the largest amount of crystals is found in the urine passed just before going to bed, and in some persons in whose urine it was observed in great abundance at night, it was entirely absent in that voided during the day.

Mucus.—At the present day it seems to be agreed that the difference between mucus and pus consists not so much in the particles themselves, as in the fluid secreted by them and in which they float. And although as a general rule the particles of mucus as observed under the microscope, are entirely distinct from those of pus, yet occasionally instances present themselves where it is almost impossible with the aid of this instrument alone, to say to which of the two the rounded bodies are to be referred. Mucus generally presents itself in large, amorphous, semitransparent masses, mixed with epithelium scales and mucus corpuscles. Fig. 8, (2.) These epithelium scales are lamellated plates,

of an irregular form and variable size, and generally have attached to their surfaces one or more of the mucus corpuscles, which have the appearance of nuclei. Bird describes them as nuclei, and as projecting always from the centre. We have observed their seat to be very variable, and have occasionally remarked them rolling over the surface of the scale and sometimes falling entirely off. The mucus corpuscles resemble in a great degree those of pus, except that instead of being round, they are rather elongated, and their internal nuclei and granular appearance are not so evident. Fig. 8, (1.) By some observers, they are supposed to be identical with pus globules, and Bird

Fig. 8.



EPITHELIUM, MUCUS, AND PUS GLOBULES.

1. Epithelium scales and mucus corpuscles. Some of these are observed in the centre of the scales, some free, and others almost in the act of rolling off.
2. Mucus, formed of an admixture of mucus globules and epithelium scales.
3. Pus globules, as they ordinarily appear in urine.

suggests that the slight difference in their appearance may depend on the greater refractive power of the fluid portion of the mucus concealing the irregularities on the surface of the mucus corpuscle from ready observation; and it is stated by Simon that if mucus be frequently observed, the transition of mucus corpuscles into epithelium scales may easily be seen, and by this transition we may explain the variety of appearances that a mass of mucus seems to be made up as observed under the microscope.

Pus consists of roundish granules somewhat larger than blood corpuscles, and more transparent. They are roughly granular on their surface, and generally give indications of the presence of a nucleus. Fig. 8, (3.) Their appearance in the urine depends entirely upon the different substances present in the secretion. In dilute acids for instance, the globules become transparent and burst, rendering their nuclei very distinct; in a solution of common salt, they assume a contracted appearance, and present a plicated and clear outline; while in distilled water they swell, become larger, and assume a spherical shape. Now although the appearance of pus in urine never varies to the degree just spoken of, yet we may often notice a difference between the globules obtained from acid and those from alkaline urine; but as a general rule we may describe them as about twice the size of blood globules, spherical in shape, and some irregular clustering at the centre may be distinguished resembling a nucleus. This becomes more evident by adding a drop of dilute acetic or hydrochloric acid, which by dissolving the cell wall, shows the nucleus to be

composed of several minute granules, very transparent, and the whole forming a compound multiple nucleus.

Blood.—When a drop of blood is placed between two pieces of glass, and examined under the microscope, the globules appear as flattened discs of a deep yellow colour, with an opaque point in their centre. Their flattened character is often rendered more apparent by their adhering together in rouleaus, but after desiccation commences, they lose their circular form, and appear irregular and contracted. Fig. 9, (1.) This latter appearance is never observed in the blood globules as they occur in urine; on the contrary, they are larger and more rounded than under ordinary circumstances, from the imbibition of the surrounding fluid. Fig. 9, (2.) It is also rare to meet with them in the rouleaus described above, and this never occurs except when blood has been effused very rapidly. A small quantity of this fluid may be present in a specimen of urine, and from the absence of any apparent colouring matter escape observation, and as blood globules after a few hours always gravitate to the bottom of the urine containing them, we may in many cases detect their existence by examining a drop of the lowermost strata, where without this precaution they would have been entirely overlooked.

Dr. David Stewart, of this city, suggested to us some time since, the propriety of adding a saturated solution of sulphate of soda to the urine, to aid in the detection of blood globules. The form they present in the urine of globular cells, is due, as we just stated, to the imbibition of the fluid in which they are contained, and the solution

of soda by giving to the urine nearly the same density as the serum of the blood allows these cells to assume their ordinary form, and they then present the appearance of flattened discs with the dark central appearance formerly described as a nucleus. By taking this precaution their recognition is easily accomplished.

Torulæ.—If any saccharine fluid be exposed to a temperature of seventy degrees for a few hours, certain

Fig. 9.

BLOOD GLOBULES, SEMINAL ANIMALCULÆ, SEDIMENT IN BRIGHT'S DISEASE, AND TORULÆ.

1. Blood globules, as they appear when dried on a glass.
2. The same in urine, they being much enlarged by exosmosis.
3. Seminal animalcules, or spermatozoæ.
4. Seminal graunles. Some of these are usually found in urine intermixed with the preceding.
5. Torulæ. Found in urine or any fluid that has undergone the saccharine fermentation.
6. Another form of the same. This last, according to our experience, is by far the most common.
7. Sediment found in Bright's disease, after Simon.

changes ensue, in the course of which oxygen is absorbed and carbonic acid given off, at the same time that certain fungoid vegetations make their appearance called torulæ, and these pass through different stages of development. The same thing occurs when sugar is present in urine, and as it may be observed when a small portion only of this substance exists its detection often becomes of importance as an aid to chemical tests. The first appearance these torulæ present is observed in a specimen of diabetic urine, a few hours after it is voided and subjected to the requisite temperature. A slight whitish scum forms on its surface, which under the microscope is ascertained to be composed of minute oval bodies. These bodies soon become enlarged, and small granules are visible in their interior, which by enlarging, give the original vesicle an elongated form. By degrees these bodies unite at their extremities, the places of union having the appearance of joints. Fig. 9, (5.) These again, after a time, break up, and the whole is deposited in the form of oval figures at the bottom of the vessel. Fig. 9, (6.) The drawings made by different writers of these torulæ, are not altogether similar, and this seems to be owing to the fact of the representation being made at different stages of the growth of the vesicles.

Sediment in Bright's disease.—In many cases of this disease a peculiar sediment, made up of different organic matters, and first accurately described by Simon, may be observed under the microscope. We have observed this appearance several times, but not often enough to consider it as important in the diagnosis of this disease. To the

naked eye it somewhat resembles mucus, but, according to Simon, is made up of five different substances: mucus corpuscles with a decided nucleated appearance, epithelium from the mucous membrane of the bladder, blood corpuscles, round dark vesicles apparently filled with granular matter, and tubes composed of an amorphous substance resembling coagulated albumen. Most of these tubes have an actual capsule, and are cylindrical, but some of them where the capsule seems to be absent, appear to be filled with an amorphous and finely granular mass, mixed up with cells and vesicles similar to mucus corpuscles. Fig. 9, (7.)

Spermatozoæ.—It is rare for a specimen of urine to contain semen in sufficient quantity to permit its detection by any other means than the microscope, and as the existence of spermatozoæ is the only certain diagnostic of the presence of this fluid, we do not think that any other means than microscopic observation is to be relied upon. They are rarely observed in motion in the urine, unless the examination is made soon after voiding the secretion, and they present the appearance of minute semitransparent oval bodies, with a hair-like prolongation about twice the length of the body. Fig. 9, (3.) When in motion this prolongation is observed to move backwards and forwards, producing a forward motion, and they become much more distinct when the urine is allowed to dry on the glass. Mixed with these there are usually observed larger rounded bodies, which are in all probability the seminal granules spoken of by Wagner. Fig. 9, (4.)

We are glad to be able to add our testimony to that of

Golding Bird in regard to the frequent existence of oxalate of lime with these bodies in the urine. In nearly every decided case of spermatorrhœa that has fallen under our notice we have been able to detect this salt, and in many cases where the disease existed as evidenced by constant nocturnal emissions, we have found oxalate of lime without being able to discover any spermatozoæ. The crystals have always been in the form of double pyramids, and generally very minute. We do not consider them as having any relation to one another more than that the habits of an individual addicted to this mode of sensual gratification are generally those which would occasion the production of this salt, as will be explained in another chapter.

It must not be supposed that the description of the different substances as given in the present chapter, includes all the varieties of urinary deposits that the microscope presents. We have done little more than point out some of their more prominent features, and day by day new crystalline forms are revealed to us which it would be impossible, in a work like the present, to detail. It is hoped, however, that the representations here given will afford a clue to all the varieties that may present themselves to the observer of this branch of pathology, and should he fail in being able to recognise those that he may see hereafter by their peculiar shape, chemical tests will almost always enable him to decide under what head they are to be included.

Again, it is rare to find a deposit made up of one sub-

stance alone. We may have several coexistent in the same field, but a little practice will soon enable the observer at a glance to distinguish them from each other, and to decide upon the relative proportions in which they are present.

CHAPTER IV.

ON THE PATHOLOGY OF THE DIFFERENT SUBSTANCES FOUND IN THE URINARY SECRETION.

Uric Acid—Urea—Phosphates—Mucus—Albumen—Blood — Pus—Cystin—Sugar—Oxalate of Lime—Spermatozoa—Kyestein.

In the previous chapters our attention has been entirely directed to the detection and estimation of the different constituents of the urine. We now purpose to examine the pathology and indications for treatment that each of them affords. In the present chapter we shall include only those elements which are most commonly met with, and confine our remarks to as brief a detail as is consistent with a general understanding. In the next we shall enter more thoroughly into particulars.

Uric Acid.—This substance is formed during the destruction of the tissues, and is the mode by which the effete nitrogen is eliminated from the system. When the influence of vitality has ceased, and the tissues become resolved into simpler elements, for the purpose of fitting them for being carried off by the different excretory organs, uric acid, choleic acid, and ammonia are formed.

The kidneys eliminate the uric acid, the liver the choleic, and the skin the ammonia. After the formation of uric acid an additional amount of oxygen is brought into contact with it for the purpose of converting it into a more soluble substance, urea; and whenever this acid is found in excess it is not to be supposed that an additional amount has been formed, but that it has not undergone the ordinary change into urea.

This substance in healthy urine, always exists in a state of combination, and is deposited only when the salt it forms is decomposed by some stronger acid, or when the excess is more than is sufficient to enter into soluble combinations. Urate of ammonia is its most common form, and although in solution at the time of emission, is often deposited after the urine cools, being much less soluble in cold than in warm water; therefore this deposit by itself would be no indication of an excess of acid.

The principal diseases with which uric acid is associated are gout and rheumatism, and although an excess is usually present in the urine before a paroxysm takes place, yet we find after the disease is once declared, and this excess deposited in one of the joints, the amount returns to its usual quantity. We can thus explain why an attack of gout so often relieves the many unpleasant symptoms that the patient laboured under before the attack. The excess of acid in the blood produced symptoms indicative of general disturbance, but after the deposition has taken place in the joints, these symptoms become entirely local. It is only after being subject for a long time to this accumula-

lation of uric acid, that the system relieves itself by depositing the superfluous quantity in one of the articulations; and we shall find that almost all individuals have subjected themselves for some time to the causes which produce an abnormal amount of this principle, and have suffered with the symptoms indicative of it, before an attack of gout took place.

The most common cause for the production of this diathesis is the continued and free indulgence in food rich in oil, together with the use of spirituous drinks, without sufficient bodily exercise; the oil and alcohol of the food requiring so large an amount of oxygen for their conversion, that there is not enough remaining to change the acid into urea. Another frequent cause is impairment of the functions of the skin, and we often find that an attack has been directly owing to suppression of the cutaneous exhalation, which being retained in the system, requires a certain amount of oxygen to change it into carbonic acid and water. We are thus shown the main difference between gout and rheumatism. The effects in both diseases are nearly the same, although very different morbid actions are brought into play to produce the causes.

An excess may exist in the blood, and yet be deficient in the urine, from some functional defect about the kidneys; or the excess may be relative, that is, it exists in its usual amount in the blood, but is not excreted. This is the case in Bright's disease, where the deficiency of uric acid as well as urea in the urine, is found to exist in the blood.

Urea.—The quantity of this substance passed from a

healthy man daily, amounts to a little more than one-third of the whole solid constituents, or about two hundred and seventy grains; and provided the assimilative organs are in a proper state of activity, its excess or deficiency is almost entirely dependent upon the amount of muscular exercise or oxygen that the individual is taking in. It is formed by the addition of oxygen to uric acid, and is increased or diminished in an opposite ratio to this substance; that is, it bears no proportion to the amount of uric acid originally formed, but is entirely dependent on the greater or less change that this substance undergoes by oxydation. It is influenced by diet, as we just explained, that is, some articles of food require more oxygen to convert them into carbonic acid and water than others, for instance, oil and alcohol more than sugar and starch; so that less oxygen would be presented to the uric acid with the same amount of exercise, if a man's diet consisted of rich food and spirituous drinks, than if he lived on farinaceous substances alone. Different conditions of the blood also influence the amount of this substance. When the globules whose purpose it is to carry oxgyen, are deficient, urea must of course be diminished; while in plethora, where the opposite condition obtains, the same amount of diet and exercise being taken, it must be increased. Being perfectly soluble, its pathological importance is very small, and the information that it affords, is as to the amount of oxygen that has been brought into contact with the uric acid.

Phosphates.—The physiology of the phosphates is ex-

plained as follows: all healthy urine contains a certain amount of fixed salts, namely, soda, potash, lime, and magnesia, in combination with hydrochloric, sulphuric, and phosphoric acids. They are derived partly from the food and partly from the transformations that are constantly taking place in the system. Dr. Jones thinks that the potash and soda are furnished by the blood and the albuminous tissues, while the lime and magnesia are derived from the fibrous and muscular. The hydrochloric acid he supposes is produced from the common salt contained in the food, and the sulphuric and phosphoric acids from the oxydation of the sulphur and phosphorus contained in the albuminous and fibrinous tissues. But whatever may be the derivation of these inorganic substances, the only ones of direct practical importance are the phosphates. The compounds of soda and potash with phosphoric acid, being perfectly soluble, always exist in a state of solution, and we have only left then for examination the phosphates of lime and magnesia. These also are perfectly soluble in the urine under ordinary circumstances, but it often happens from some cause inherent in the solution, or when decomposition has taken place, that ammonia is liberated. This alkali then unites with the phosphate of magnesia, forming a phosphate of magnesia and ammonia, or as it is usually called, the triple phosphate, and from its being insoluble in water alone, or in an alkaline solution, its pathology becomes of importance.

It will be seen by reference to the preceding chapter, that the crystals of this salt, when formed spontaneously

in the urine as a result of decomposition or otherwise, have a different shape from those formed by the addition of ammonia in a test-glass; the first being prismatic, while the latter are stellated. The reason usually alleged to explain this difference is, that in the last case the salt has double the quantity of ammonia that it has in the first; but at another place we will show the greater probability of its being due merely to the rapidity with which crystallization takes place.

When these salts exist in the urine as a deposit, they are usually indicative of serious disturbance, and often of organic disease, unless they have occurred as a result of decomposition. But to this there are exceptions; for instance, medical students, or those who breathe for any length of time an atmosphere charged with ammonia, are liable to suffer with a deposit of this salt in their urine. It has also been observed in convalescence from acute disease, and in some cases of indigestion. But with these exceptions, it is most often found associated with a calculus in the bladder, or some organic mischief of that organ or the kidneys. There is always coexistent with the presence of this salt in the urine, a depressed state of nervous energy, sometimes local only, but at others general. For instance, we find it frequently in persons who are old and infirm, or in those who have received some blow or strain over the loins. The general symptoms are those which are consequent upon depressed nervous energy, and almost all persons suffering with this condition of urine, are regarded as labouring under hypochondriasis, or severe dyspepsia.

Mucus.—The conditions upon which an excess of mucus depends are entirely local, for the bladder and urethra like other mucous membranes, throw off a large amount of mucus in certain states of irritation and inflammation; and we find consequently that an excess is almost always coincident with some abnormal deposit, particularly phosphates, a calculus in the bladder, or a stricture of the urethra. It may occur, however, from simple catarrh, as in other mucous membranes. Most frequently it is found associated with a deposit of monobasic phosphates, sometimes as an effect by the irritation they have produced on the bladder, but most often as a cause. Mucus acts on the urine as a species of ferment, and quickly produces decomposition, by which ammonia is liberated, and the triple phosphate deposited.

Albumen is the first abnormal element found in the urine, whose pathology we shall take into consideration. Its presence is always due to some obstruction in the circulation of the kidneys, so that congestion of these organs is produced, and the serum of the blood filters through in the same mode that the fluid of dropsy is effused into the cellular tissue of the extremities or the peritoneal cavity, when obstruction exists to the passage of the blood through the heart or liver. Now the cause of the obstruction in the heart or liver may be owing either to simple congestion, inflammation, or chronic organic change, and these same causes produce an effusion of fluid from the kidneys; but the result of the effusion in the two cases is very different. In the peritoneal cavity, or the cellular tissue of

the extremities, the serum remains unchanged until absorption takes place, or artificial means are resorted to. But when effusion from the kidneys occurs, the fluid passes into the pelves of these organs, from thence to the bladder, and is discharged with the urine. For it must be remembered that in urine where albumen exists, the other elements of the serum are to be found at the same time, for it is not albumen alone that is secreted, as was formerly thought, nor is the serum due to any fault of secretion on the part of the kidney more than its mere physical condition. The most common organic change that these organs undergo, is in what is termed Bright's disease, or granular degenerescence, and here the albumen is produced in the same way. By the deposition of granules in the cortical portion of the kidneys, their secretory function is interfered with, and at the same time by pressure on the circulating vessels, obstruction ensues, and the same result occurs as where congestion has been produced by other causes.

Simple congestion is by far the most common mode by which this substance is produced in the urine, and may be dependent upon several conditions: such as external injury, the retrocession of a cutaneous eruption, certain febrile states of the system, checked perspiration, weakness of the renal vessels, pressure on the veins, and stimulating diuretics. It is very commonly found in the urine during the dropsy that occurs as one of the sequelæ of scarlet fever. Here the functions of the skin having become impaired, additional duty is forced upon the kidneys, which as a consequence become congested, and per-

form their functions with difficulty. Any accidental cause which increases this congestion, produces a corresponding difficulty in these organs for eliminating their proper secretion, until at last the serum of the blood only, with its contained albumen, filters through; while the urea and uric acid are retained in the blood, and the water, with a small portion of albumen in solution, is deposited in some of the loose tissues in the form of dropsy. It will be seen by this, that the presence of albumen is far from uniformly indicating Bright's disease, or granular degenerescence of the kidneys; and this is only to be suspected when the disease is of a chronic form, and attended by symptoms pointing particularly to that affection.

Blood is found in the urine from a variety of causes; but its presence is always indicative of either active or passive hemorrhage. Should coagula be present, we know that there is somewhere a breach of surface, either from excessive congestion, or mechanical violence, as from the irritation of a calculus, or the introduction of an instrument into the urethra, and it may sometimes take place from fungoid disease. Its most common cause is congestion of the kidneys, produced by derangement of the cutaneous function, or by pressure on the renal veins as in pregnancy. We invariably find in these cases that there is a great diminution of urea and uric acid, while at the same time, the quantity of urine passed, is much below the usual amount. The difference in the producing cause of blood or albumen in the urine, is one merely of intensity. If the obstruction is so great as to produce rupture, blood

is effused; otherwise serum alone. The natural secretion is of course diminished in both cases, because the secreting portion of these organs is unfitted for use by congestion; but on examination, these substances will be found in the blood, in a proportion sufficient to counterbalance their deficiency in the urine.

We have occasionally seen in a healthy individual after exposure to cold, while the skin was acting freely, this state of things occur, and be promptly relieved by warm-baths or any means that acted revulsively on the kidneys, and tended to diminish their congestion. Bloody urine has also been found to occur during the course of grave fevers, in scurvy, and in those diseases in which the blood is in an altered condition. It may also occur from vicarious menstruation.

Pus.—The presence of this substance in the urine is almost always indicative of the existence of suppurative inflammation in some part of the urinary apparatus. An abscess, however, in any of the adjoining organs, may by ulceration, discharge itself through the bladder or kidneys; and we should also remember that an inflammatory condition of the urethra, as in gonorrhœa or gleet, often produces a purulent discharge without there being any evidence that ulceration exists. It is difficult to say in many cases, whether the pus found in the urinary secretion proceeds from the bladder, the kidneys, or the prostate gland; but the period at which it is voided will often afford material assistance. The patient should be directed to lay upon his back, and after remaining quiet for some time, to void

different portions of his urine in three or four separate vessels. By examining these separately, we ascertain whether the pus is principally contained in the first or last portion. If in the first, we may reasonably conclude that the difficulty is seated in the prostate gland, which will be strengthened by ascertaining that this organ has undergone some alteration in size or consistence. If on the contrary, the pus is contained in the vessel in which the last portion of the urine was voided, it proceeds in all probability, from the bladder; for this substance being heavier than urine, by gravitation falls to the lowest part of the bladder, which, in a recumbent position, is nearly opposite the orifice of the urethra; consequently the upper stratum of urine, or that first passed, would be nearly free from sediment.

Cystin.—Our information in regard to the pathology of this substance is very limited, and little that is satisfactory is as yet known. Its composition is exceedingly remarkable, from the fact of its containing no less than twenty-six per cent. of sulphur. It was first recognised as a constituent of a calculus submitted for examination; and it is only within a few years past that it has been found existing as a urinary sediment. In a majority of cases it seems to be connected with a scrofulous diathesis, and often with organic disease of the liver; but, nevertheless, is frequently found without being associated with any appreciable disorder, except the formation and discharge of a calculus. In three well-marked cases spoken of by Garrod, one occurred in a young man affected with dyspepsia, a second

was suffering from an abscess in the perineum, and in a third the appearance of cystin was first observed during an attack of acute rheumatism, complicated with heart disease and pneumonia. We have observed it in one well-marked instance. The patient was a mulatto girl, with scrofulous enlargement of the cervical glands, who applied to be treated for dyspepsia. Two specimens of her urine voided at intervals of a week, contained it in an appreciable quantity; but she did not afterwards return, and further insight into her condition was lost sight of. It is no doubt formed during some of the processes of secondary assimilation; and is in all probability derived either from albumen, or from the tissues into which albumen is changed.

Sugar.—Formerly all diseases in which the prominent symptom was an increased discharge of urine, were included under the head of diabetes; but a distinction was made between diabetes mellitus, and diabetes insipidus; the latter consisting merely of an increased discharge of urine dependent upon a variety of circumstances which we have already explained, the other always characterized by the presence of a certain amount of sugar in the urinary secretion. Of late years, however, the term diabetes is confined entirely to the latter condition. The disease is comparatively a rare one, and is much less frequent in this country than in England, where Dr. Prout states that in twenty-five years, more than five hundred cases of it have fallen under his observation.

Its pathology, in spite of the attention that has of late

years been bestowed upon it, is still obscure in many points. We know that it is essentially a disease of digestion, and that the kidneys are not concerned, except in eliminating a material which can take no part in any of the various functions of digestion and assimilation.

In a healthy individual all saccharine or amylaceous substances taken into the stomach, subserve the purposes of respiration, and are thrown off in the form of carbonic acid and water. But in the present instance, from some fault of primary digestion, this change does not take place, the sugar passes into the blood as sugar, and is eliminated by the kidneys as such. The most plausible explanation to account for this condition of things, is that offered by Bouchardat, who thinks that from the presence of a peculiar substance in the stomach of a healthy man, which he has isolated, similar to the diastase which produces the saccharine fermentation in barley, all the starch and saccharine material contained in the food become changed into sugar while still in the stomach. And although in a healthy man this same conversion into sugar takes place from the same substances, yet the change is not effected until the addition of the pancreatic juice. For if the latter be forced to throw off the contents of his stomach shortly after a meal, before this latter secretion is added, we never find them converted into sugar, while in a diabetic patient it is invariably present. Again in a healthy man, the sugar is formed slowly, enters by degrees into the circulation, and is readily gotten rid of as carbonic

acid and water, but when formed in the stomach it passes quickly into the blood, and can then only be eliminated by the kidneys abstracting it in its original form.

The quantity of urine voided in this disease almost always exceeds that of health, and is sometimes enormous. From ten to twenty pints are usually passed daily, and occasionally as much as forty or fifty pints, or even more, and this average may be sustained for weeks or months together. But this amount bears a regular proportion to the quantity of sugar excreted, which always abstracts sufficient fluid from the blood to insure its solution, and to supply this continual drain from the blood, enormous quantities of fluid are taken into the stomach. The skin is invariably dry, and the patient usually suffers from constipation, because all the fluid ingested is required to dissolve the sugar, and in this form is quickly abstracted by the kidneys. The urea and uric acid are always diminished, but this diminution is a relative one only. The normal proportions are excreted in the twenty-four hours, although the large quantity of water in which they are dissolved, reduces their amount in each ounce of fluid to very little. When the disease is far advanced there are three symptoms invariably present, these are thirst, emaciation, and the discharge of an increased amount of urine. When these are coexistent, and have been present for some time, we may always suspect the existence of the disease under consideration.

Oxalate of Lime.—In the beginning of this chapter it was stated that urea was formed from uric acid by the ad-

dition of a certain amount of oxygen, and that an excess of uric acid in the system was to be attributed, not to any additional amount being formed, but to the fact of its remaining unconverted into urea. Now, if a less amount of oxygen be brought into contact with this acid, there results the formation of a certain quantity of oxalic acid, and a smaller amount of urea. In other words, oxalic acid is intimately associated with uric acid, and is a disease produced by deficient oxydation. Lime unites with this acid in preference to any other, and as all urine contains a certain amount of it, this substance invariably exists as an oxalate of lime. It is the most common of all urinary deposits, but cannot always be looked upon as constituting a disease. Any cause which prevents an individual from receiving a due supply of oxygen is liable to produce it, but it is only when it exists in sufficient quantity to occasion general symptoms indicative of its presence, that it becomes of sufficient importance to require treatment. Thus, in the urine of individuals leading a sedentary life, such as the inmates of a prison, or those whose professional avocations require them to remain in close, ill-ventilated apartments, this salt is very commonly found.

Oxalic acid may also be formed during the processes of primary digestion, and inasmuch as all the cases in which oxalate of lime is found associated with so decided a departure from health as to require treatment, are attended with more or less disorder of this function, it would seem that those cases only ought to be included under the head of "the oxalate of lime diathesis," in which the oxalic acid

is formed in this way. In primary digestion, among the changes that take place is the formation of lactic acid, the carbon of which, if the requisite amount of oxygen is taken in, becomes converted into carbonic acid. But if a less quantity of this gas is presented to the lactic acid, carbonous or oxalic acid is formed. This in its turn produces the same derangements of the digestive organs and depression of nervous energy, that are occasioned by its introduction into the stomach in the ordinary way. Accordingly we find that the mere presence of oxalate of lime in the urine is not to be regarded as evidencing a diseased condition, unless at the same time there is some derangement of the digestive organs, accompanied with depression of nervous energy. The reason for this difference is easily explained. When oxalic acid is formed in the stomach it enters the blood, and passes through the whole round of the circulation before it is eliminated by the kidneys. It consequently has ample time to produce its physiological effects upon the nervous system. Whereas, if it is formed in the blood from uric acid, although a part of it may pass through the entire round of the circulation, yet on the other hand the greater portion of it may be eliminated almost as rapidly as it is formed.

Neither the quantity of urine passed, nor its appearance, afford us any particular evidences of the presence of this salt, nor are the proportions of urea and uric acid at all affected by it, they being influenced in a great measure by the quantity and quality of the aliment, as we have already explained in speaking of uric acid.

Spermatozoa.—The presence of these animalculæ in the urine has no connexion with the condition of the bladder or kidneys, and if micturition has not been preceded by sexual connexion, after which act some of these bodies would remain in the urethra, they denote the existence of seminal emissions. Their detection in the urine after connexion may be of importance, as proving the individual capable of procreation, but their absence under these circumstances could not be alleged as evidence to the contrary.

Kyestein as yet, with the exception of the pulsations of the fœtal heart, is the only decided evidence we possess of the existence of pregnancy. In a few instances Kane observed it during the first weeks, but it most commonly makes its appearance during the seventh, eighth, and ninth months up to the period of delivery. It is not a constant symptom, although present in a large majority of cases. It also makes its appearance during lactation, but this rarely happens, unless from some cause the secretion of milk becomes checked. In eighty-five cases of pregnancy reported by Dr. Kane, it was absent only eleven times, and was present in thirty-two out of ninety-four cases examined during lactation. This substance has a very close relation with casein, and it would seem that it is in the course of preparation during pregnancy, being eliminated by the kidneys until the mammary glands are prepared for the performance of their functions. Simon observed it but once on the surface of a man's urine, and that after

standing three days, and he remarks in relation to its value, "From the observations of Kane and myself it seems to follow that pregnancy may exist without the occurrence of kyestein in the urine; if, however, there is a probability or possibility of pregnancy, and kyestein is found, the probability is reduced almost to a certainty."

CHAPTER V.

ON THE PATHOLOGY AND THERAPEUTICAL INDICATIONS OF THE MORE IMPORTANT ELEMENTS OF THE URINARY SECRETION.

Composition of the Urine—Its derivation—Quantity of Water—Hysteria—Urea and Uric Acid—Their derivation—Objections to Liebig's Theory explained — Gout and Rheumatism — Difference between the two—Chemical Theory alone untenable — The Influence of the Nervous System — Treatment—Diet—Hydropathy—Internal Remedies—Hippuric Acid—Experiments on the changes Benzoic Acid undergoes—Case I. of Gout—Phosphates—Relation of Phosphoric to Uric Acid—True and false Diathesis—Treatment—Stellar and Prismatic Crystals not different salts, as heretofore assumed — Albumen — Due to congestion—Objections to Prout's Theory—Oxalate of Lime—Formed from Uric Acid—May be formed without Urea—Objections to Bird's Theory—Commonly found in the Urine of Convicts—In persons suffering from Spermatorrhœa—Dumb Bells probably not Oxalate of Lime—May be formed from Uric Acid—Relation of Ovals and Dumb Bells to one another—Uric Acid Theory insufficient to account for all cases of Oxalate of Lime—It is also due to defective conversion of Lactic Acid—Treatment — Case II. — Case III.—Case IV.—Diabetes — Pathology more obscure than the preceding—Professor Graham's Experiments—Bouchardat's Theory—Mialhe's Theory—Symptoms—Treatment.

The kidneys are the emunctories by which the effete materials, which can no longer subserve any of the pur-

poses of nutrition, and the accidental substances, whose retention would be injurious, are eliminated from the system. In the performance of this function they allow the passage of certain substances with little or no change, as water, uric, and hippuric acids, urea, and certain salts; while they decompose others, and eliminate the products of this decomposition in certain forms which in all probability, did not previously exist in the blood. We have already explained the variety of causes that influence both the quality and quantity of the urinary secretion, and, in the present chapter, do not purpose to go into a minute account of the pathology of all the different elements previously mentioned, but shall speak only of those whose importance demands a more detailed account than has been already given.

We have found that the urine consists of water and solid contents; the last may be divided into an organic and an inorganic portion, and the organic portion be again divided into several elements. These are mucus, epithelium, urea, uric, and hippuric acids, kreatine and kreatinine, extractive and colouring matters. Of these mucus and epithelium are derived from the urinary passages; kreatine and kreatinine are nitrogenous bodies, whose properties have been closely studied by Liebig within the last few years. They are both found as constituents of muscular tissue, and kreatine contains in union with other substances, the elements of urea. Their pathology in relation to the urinary secretion, is as yet but little understood, but they are in all probability due to defective conversion, and hold an inter-

mediate place between the devitalized tissue and uric acid. They were mistaken by Berzelius for lactic acid, and described as such by him, but the latter contains no nitrogen. Of the extractives and colouring matters little satisfactory is known. Garrod thinks the latter are derived from the blood, because, when suppression of urine exists, the uric acid thrown down from the blood is strongly tinged, while in those cases where the acid alone is retained, it is precipitated of a light colour. There remain then of these for our present consideration, urea, uric, and hippuric acids.

The derivation of the inorganic matters is more easily explained. They consist of soda, potash, lime, and magnesia, in combination with hydrochloric, sulphuric, and phosphoric acids. The alkaline phosphates are derived from the food and the oxydation of the albuminous textures, the earthy phosphates and sulphates from the food also, and the disintegration of the tissues, while the presence of the chlorides being in part due to the muriate of soda taken in with the food, is found to be much influenced by the quantity and quality of the aliment used.

We have seen that both the quantity and the composition of the urine vary greatly, not only in different individuals, but in the same individual at different times; and, inasmuch as one of the important offices of the kidneys is to preserve the amount of fluid in the blood in proper proportion to the wants of the economy, and at the same time to be a counter-balance to the perspiratory function, it will be found that the amount of water contained in the urinary secretion, will be greatly influenced by the quantity of fluid

taken into the system, and the condition of the cutaneous exhalation. In addition to this, the amount of salts contained in the ingested fluid, determines its action at one time upon the alimentary canal, and at another upon the kidneys. If it contains less salts than the blood, on the principle of exosmose, the fluid enters the blood; but if more, the fluids of the body pass out, and purgation ensues. All the inorganic acids and their bases, with the exception of the phosphoric and sulphuric acid, which owe their origin principally to the transformations of the tissues, are contained in the food, and are removed by the kidneys from the blood because they are no longer useful for any of the purposes of the economy.

An excess of water in the urinary secretion from any of the above-mentioned causes cannot be considered as abnormal; but instances of a more permanent character are occasionally met with, not owing to hysteria or to the presence of sugar, which produce great discomfort to the individual, occasion thirst, and are persistent for a long time. The pathology of these cases is extremely obscure, but we find that they frequently produce great debility and loss of flesh. They occur in excitable nervous individuals, particularly dyspeptics, and Willis relates an instance of a man, who for some time, passed on an average in the twenty-four hours, thirty-four pounds of urine, while the fluid taken in amounted to a much smaller quantity. In hysteria, we find that the patient voids a large amount of nearly colourless urine, which on examination is found to be of an exceedingly low specific gravity, and containing

scarcely any of the usual materials in solution, although, after the paroxysm has passed, this deficiency is counterbalanced by the secretion of an increased amount of solids. This can only be explained by supposing that during an attack, there is such an abnormal distribution of nervous energy, that the usual amount is not sent to the kidneys, which merely allows the water to filter off without their eliminating the solid materials, which it is their function to excrete. These of course accumulate in the blood, and are excreted in increased quantity after the paroxysm has subsided.

UREA AND URIC ACID.

The phenomena of increase and waste in the animal body may be divided into three different stages. The first of these is nutrition, during which the matters capable of subserving the purposes of respiration, or of being transformed into living tissue, undergo digestion in the alimentary canal, and pass from thence into the circulation. The second, which may be called the transition stage, includes all the primary formations of secondary assimilation; such as kreatine, kreatinine, and sarcosin, with lactic and inosinic acids. The properties of most of these are still very obscure, and although two of them, kreatine and kreatinine, always exist as constituents of healthy urine, it is probable that their presence is only accidental, and entirely dependent upon defective conversion. The third of these stages is the excretory, and includes all these pro-

ducts which, being fully formed, it is the purpose of the different excretory organs to eliminate from the system. These are, urea, uric acid, ammonia, carbonic acid and water. According to Liebig's formula

	C	N	H	O		C	N	H	O	
1 atom of blood, .	48	6	39	15		38	1	32	11	. 1 atom cholcic acid,
1 " water, .			1	1		10	4	4	6	. 1 " uric acid.
1 " oxygen,				1	=		1	3		. 1 " ammonia.
	48	6	40	17		48	6	40	17	

Now, cholcic acid by combining with soda constitutes bile, which, after being poured out into the duodenum to effect certain changes in the chyme, which it is not our province to explain here, enters the circulation, becomes oxydised and is eliminated by the skin and lungs in the form of ammonia, carbonic acid, and water. Thus:

	C	N	H	O		C	N	H	O	
1 atom cholcic acid,	38	1	32	11		38			72	38 atoms carbonic acid.
90 " oxygen, . .				90				29	29	29 " water.
					=		1	3		1 " ammonia.
	38	1	32	101		38	1	32	101	

The ammonia of both formulas is eliminated by the skin as lactate of ammonia, and although this alkali is always found in a certain amount in the urine, it is doubtful whether it ought to be considered as a healthy product, or rather as owing to defective secretion on the part of the skin. But this subject we will discuss at another place.

The physiology of uric acid is then the only one we have

left for our examination at present. We have just shown without going through the intermediate steps, that according to Liebig's formula, this acid, together with the other elements destined for excretion, is formed by the oxydation of the effete tissues over which the influence of vitality has ceased, and we shall assume the same author's hypothesis to explain the changes that this substance subsequently undergoes. Uric acid requires nearly ten thousand parts of water for its solution. It cannot therefore exist in an uncombined state. Golding Bird supposes that, "at the moment of its separation from the blood, it meets with the phosphate of soda, and ammonia, and forms lithate of ammonia, while phosphoric acid is liberated, giving to the urine its acid reaction." Liebig on the contrary asserts, from the well-known property which the bibasic phosphate of soda possesses of dissolving uric acid at high temperatures, that this acid exists in the urine under the form of urate of soda, while the monobasic phosphate thus formed gives to the secretion an acid reaction, and this to us seems more reasonable than the explanation offered by Bird, for, we find that the quantity of ammonia in the urine is exceedingly variable and dependent upon various circumstances. In an individual lightly clad, following a laborious occupation in the open air, and in whom the functions of the skin are freely performed, this alkali, either free or combined, is rarely present; while on the contrary, if the reverse is the case, and the individual warmly clad, leads a sedentary life, the cutaneous exhalation is retained, and a portion of it eliminated by the kidneys. It is probable,

that were man again in his primitive condition, and forced to gain his bread by the sweat of his brow, neither ammonia or uric acid would ever be found as constituents of healthy urine; the first, being eliminated by the skin, and the other entirely changed by the action of oxygen into urea.

Let us now examine the relations of this acid to urea, and the conditions necessary for the conversion of the one into the other. This the following formula explains.

	C	N	H	O		C	N	H	O	
1 atom uric acid, .	10	4	4	6		4	4	8	4	2 atoms urea.
4 " water, . . .			4	4						
6 " oxygen, . .				6	=	6			12	6 " carbonio acid.
	10	4	8	16		10	4	8	16	

It is thus shown that one atom of uric acid by the addition of four parts of water and six of oxygen, may be changed into urea and carbonic acid. In other words, that uric acid by undergoing oxydation becomes resolved into two simpler substances than the original combination; and in what follows, it will be shown, that the increase or deficiency in the urine of either uric acid or urea, is to be referred entirely to the greater or less amount of oxygen taken in by the living body.

Some objections founded upon practical results have been advanced against this explanation, but on close examination it will be found that they are rather apparent than real. In the first place, it follows from what has been already said, that the amount of food remaining the

same, an excess or deficiency of urea in the same individual must depend on the greater or less quantity of oxygen brought into contact with the already formed uric acid; the composition of the food does not exert any influence over the formation of uric acid; but as oil and alcohol require more oxygen for their conversion into carbonic acid and water, than starch and sugar, and these last more than muscle itself, if the same amount of oxygen be constantly taken in, there will be more presented to the uric acid, when the diet consists principally of meat, than when oil and alcohol alone are taken into the stomach. We shall, hereafter, in speaking of gout, see the practical application of this. In animals, therefore, who undergo a large amount of muscular exertion and live entirely on meat, the conditions necessary for the formation of urea exist in the highest degree, and it is found that the urine of lions and tigers contains no uric acid, its place being entirely supplied by urea; that is, that their active habits necessitate the respiration of a large amount of oxygen, little of which, is required for the conversion of their food; so that although uric acid is formed in these animals as in man, by the process of disintegration, yet there is oxygen sufficient brought in contact with the acid to convert it all into urea. And it is probable, as we before stated, that were man again reduced to the condition of a savage hunter, the same conditions then obtaining as in the animals just mentioned, we should find his uric acid entirely replaced by urea.

If, on the other hand, we examine the urine of those individuals who take into their systems a large amount of fat, and who at the same time, from insufficient exercise

respire but small quantities of oxygen, we find the uric acid in large amount, with a corresponding deficiency of urea. We have examined with this view, the urinary secretion of a large number of convicts in the Maryland Penitentiary, who, day by day, take in the same amount of food, and undergo but little active exercise in the open air. In those employed in the most sedentary occupations, little urea is found, but a large amount of uric acid; in the blacksmiths, there is a larger amount of urea, with a corresponding diminution of the acid; and in but two or three individuals, and those employed as runners and messengers, are these substances found in their normal proportions. To a considerable number of these persons cod-liver oil was administered. They were kept on the same diet, and at the same work. We found the quantity of urea diminished still lower, and in a proportion corresponding to the amount of oil taken by each individual.

In serpents, the conditions necessary for the oxydation of their uric acid are entirely wanting,—their sluggish habits only enabling them to take in sufficient oxygen to form uric acid, without the conversion going any further. Birds, it is alleged do not follow this rule, their excrements consisting entirely of uric acid in the form of urate of ammonia, although their habits, it is said, necessitate the consumption of a large amount of oxygen. Now, this objection, it seems to us, is scarcely a valid one. It is true, that Liebig examined the fæces in the rectum of a buzzard, and found them to consist in great part of urate of ammonia, and it is well known that the manure called

guano, which is the excrement of a certain class of sea-birds, is composed of almost entirely the same substance. But the habits of the buzzard are, in many respects, similar to those of serpents; after gorging itself to an extreme degree with food, it remains comparatively inactive for days, so that the oxygen is taken in in small quantity, and so large a proportion of it is required for the conversion of the animal's food, that its uric acid passes out unchanged.

Again, sea-birds live almost entirely on fish, most of them containing oil, which requires a large amount of oxygen to convert it into carbonic acid and water. They are at the same time so sluggish in their habits that in a large class the wings are but scantily developed; so that respiring but a small quantity of oxygen, and most of it being required for the changes that its food must undergo, we would scarcely expect that enough would remain to effect any alteration in the uric acid. Moreover, the comparison between the urinary secretion of birds and that of man is scarcely a fair one. For there can be no doubt that many substances which in man are gotten rid of by the secretions from the skin and alimentary canal, are in birds eliminated by the kidneys.

The opponents of this theory urge also that, according to Liebig's views, uric acid should be diminished in fever, inflammation and phthisis, where oxygenation is going on rapidly, and increased in chlorosis and anæmia. This is true with some reservations. It does not follow that because an individual is labouring under fever or inflamma-

tion, that he must be necessarily taking in an increased amount of oxygen. The perfection of oxygenation is dependent upon the greater extent of surface in the lungs, the rapidity and strength of the respirations, and the quantity of blood-globules whose purpose it is to receive the oxygen as it is respired. When all these are at their maximum, the greatest amount must be taken in. But in phthisis, two of these conditions are notoriously wanting: the respiratory surface of the lungs and the quantity of globules being always diminished. In an inflammation such as pneumonia, the lungs present less surface, and in hepatitis they are prevented from free expansion. All these causes would modify the quantity of oxygen taken in, so that we might or might not find the amount of uric acid always diminished. We will take remittent fever as an illustration of the changes that the essential fevers may produce in the urine. In this disease we have, as one of the pathological alterations, acute inflammation of the stomach and duodenum, and the quantities of bile ejected by vomiting are as much due to the irritation transmitted from these organs to the gall ducts as to any absolute increase in the bile itself. But the more of this substance there is ejected from the stomach, the less there will be remaining for the oxygen to convert into carbonic acid and water, and, as a consequence, the more oxygen to act upon the uric acid. So, we see that in this disease at least, the greater or less quantity of urea will be very much influenced by the amount of bile ejected from the stomach.

Again, the increase or diminution of uric acid is not to be considered absolutely but relatively to the urea, for the same amount is not formed under the same circumstances in each individual. Taking this view of the case will explain those objections to Liebig's theory which are founded upon the amount of these substances in the urine in chlorosis. In Becquerel's cases of this disease, quoted by Bird, page 75, it is true, that, although the maximum of five cases shows the uric acid to be increased relatively, the minimum of five others indicates a decrease. But the average of eight cases of uncomplicated chlorosis examined by L'Heretier and quoted by Simon, shows the uric acid to be five grains, and the urea one hundred and twenty-three grains in twenty-four hours, a ratio of 1 to 24·6; while in health we find it to be only 1 in 33·3. In one of Simon's cases, stated on page 495, the ratio is as high as 1 to 8, while in another it is only 1 to 41·5. These discrepancies are in all probability to be accounted for by variations in diet and the amount of exercise taken, and do not at all interfere with the fact that all things being the same, uric acid will be increased relatively in chlorosis; and we have merely examined these cases to show, that unless a great many conditions are taken into account, analyses of these principles in different diseases can neither invalidate nor prove the theory in relation to their formation as laid down by the philosopher of Geissen.

The use of purgatives, provided they do not produce serous discharges, also diminishes the amount of uric acid

and increases that of urea in the urine; not by any specific property inherent in them, but merely by carrying off the contents of the alimentary canal, a portion of which would require a certain amount of oxygen for its conversion into carbonic acid and water, and thus enabling the additional oxygen to act upon the uric acid.

Dr. Lehmann, in a series of experiments instituted upon himself in regard to the influence of different kinds of diet upon the formation of uric acid and urea, found that while living exclusively on animal food, both these substances were at their maximum, and under the use of one entirely non-nitrogenized they were both at their minimum. Now, these results do not at all agree with what we have previously stated, but we must recollect that two important conditions do not seem to have been considered by him. These are the amount of oxygen taken in, and the relative proportions of oxydizable food; and we may state, moreover, that these experiments of his stand alone, and in entire opposition to the numerous results obtained by others. For it will be seen that the amount of urea in his experiments is nearly three times as much as that excreted by an individual in a state of health, while at the same time the uric acid, instead of being diminished, is increased proportionably to the same extent,—an absolute impossibility, according to the views of Liebig, now so universally acknowledged.

It must be seen by what has preceded, that whatever be the proximate cause of an excess of uric acid in the urine, existing either in solution or as a deposit, the remote one

is always a deficient supply of oxygen. It is true that this substance is often deposited when the quantity of water secreted by the kidneys is insufficient to retain it in solution, and this may arise from the skin acting too freely, or from there being too little water in the body generally, from a deficient supply of fluid. Again, if exactly the opposite state occurs on the part of the skin, that is, diminished secretion, a deposit may occur from a different cause. It is usually explained by saying that the kidneys are forced to eliminate the matters normally excreted by the skin. A portion of these, as the ammonia, it does excrete, but the lactic acid with which it is in combination, is got rid of by converting it into carbonic acid and water; and as this change necessitates the use of oxygen, there will be less of this element to act upon the uric acid and convert it into urea. It must not be supposed that whenever there is a deficient quantity of water in the urine, or when the cutaneous exhalation is not properly eliminated, that there must of necessity be a deposit of uric acid. In a majority of cases this occurs only when the acid is already in excess, and in an individual labouring under this diathesis, checked perspiration is more frequently the exciting cause of a direct attack. It has been proved also, that tartaric, citric, and some other of the vegetable acids may pass through the circulation, and make their appearance in the urine as tartrates, citrates, &c. This explains why acid wines are in many instances more productive of gout than pure whiskey or brandy. In the first case we have thrown into the circula-

tion alcohol as well as some acid, and this latter by combining with the base with which the uric acid is in union, produces a deposit of this substance although no excess is present.

The two diseases in which uric acid plays the most important part are gout and rheumatism, and to these may be added a third, the assemblage of symptoms produced by the presence of a uric acid calculus. The latter, however, is a mere mechanical disease, and the symptoms produced by its presence in the bladder or kidneys are merely those of local irritation. We do not understand the term gout as merely indicating a deposit of uric acid or urate of soda in the small joints of the extremities, but recognise it as embracing all the disorders, wherever located, produced by the presence of uric acid and usually included under the head of anomalous symptoms of gout. In these two diseases, gout and rheumatism, the acid is deposited in the tissues about the joints, because it is in these parts of the body that the circulation is less active; they receive less blood and as a consequence, less oxygen, and it is here, therefore, that any defect of the conversion into urea, would be first experienced. In the other form of disease where a calculus is formed, the uric acid is excreted by the kidneys, but, owing to its excess or to the bladder containing something out of which a nucleus may be formed, it becomes deposited and in the course of time forms a calculus.

On examining into the original causes of gout, we find them referable to a sedentary life and a diet rich in fat

and alcohol. That is, the fat and alcohol require so large an amount of oxygen for their conversion, that nearly all which the insufficient exercise of the individual enables him to take in is consumed for this purpose, and little or no urea is formed. But after the joint becomes altered by one or more deposits, it is more liable to simple inflammation, and attacks may then occur consisting of simple inflammation alone, without any increase of acid in the system at large. Liebig explains the difference between gout and rheumatism to be, that in the first the deficient oxydation of the uric acid is owing to the food, rich in oil and alcohol, appropriating it, while, in rheumatism, the oxygen is consumed in oxydizing those matters which should otherwise have been excrcted by the skin. The principal cause of rheumatism it is well known, is the action of cold upon the skin, by which its exhalation is retained, and the lactic acid, which is one of its constituents, instead of passing off as lactate of ammonia, is retained in the blood, becomes oxydized and is eliminated as carbonic acid and water. This conversion is produced at the expense of the uric acid, which thus unoxydized is deposited in those tissues where the least blood circulates, that is, the articulations. But there are two elements united to make up this disease in its inflammatory form; the first being the deposit of uric acid, and the second the local inflammation set up around the joint as a consequence of the irritation it has produced. So that in a therapeutical point of view, the efficacy of bloodletting will entirely depend on the presence or absence of local inflammation;

for after a time the joint becomes accustomed to the irritation, and in those individuals who from repeated attacks have merely urate of soda deposited, without subsequent changes ensuing, our efforts must be almost entirely directed to the removal of these concretions.

It must not be supposed that in explaining thus chemically the phenomena of gout and rheumatism, and their relation to each other, that we consider chemical laws the sole agents in the production of these diseases. If a deposit of uric acid in the joints were entirely due to chemical processes, we ought to be enabled to produce these diseases at will, by merely subjecting the individual to those causes which prevent a due supply of oxygen. But we do not find that the poor labourer, who, day by day, in a constrained position breathes an impure atmosphere, is liable to gout, although in an insufficient supply of oxygen, he would seem to be subjected to the necessary causes for the production of an excess of uric acid. But the explanation is this. Uric acid may exist in great excess in the blood, but so long as the nervous system continues in full activity, and there is no physical defect on the part of the kidneys, these latter secrete all the acid that is presented to them. But should the nervous influence be withdrawn, although no greater amount of uric acid is present than before, the kidneys perform their function imperfectly, and the acid is deposited in some of the articulations. Should this accumulation take place suddenly, as in rheumatism, it is immediately deposited in those articulations which present the greatest surface, but if the excess is accumu-

lated by degrees as in gout, it is in the small joints or those most removed from the central organ of the circulation, that this defective conversion of the uric acid is first experienced.

Among the individuals most prone to gout, are those who lead a laborious, and at the same time a sedentary life. But their sedentary habits are not the sole cause of the disease. They may be termed the predisposing causes, and the wear and tear of the brain, overtaxed by anxiety and toil, prostrates the nervous system, and produce the same effects though from a different cause that are experienced by those addicted to slothful habits, and given up to the gratification of the pleasures of the table.

Although this acid, so long as it remains in solution in the urine, produces no symptoms that call for active interference, yet its excess is an indication for preventive treatment. We have spoken heretofore of uric acid, without mentioning the forms in which it usually exists. It is never found deposited in the joints as uncombined acid, and rarely in the urine; in the first, existing as lithate of soda, and in the latter as lithate of ammonia. We can readily understand, that when the functions of the skin are interfered with, and the ammonia becomes eliminated by the kidneys, that uric acid, which has a strong affinity for ammonia, should exist as a urate of that substance. But if healthy urine be evaporated under the air-pump, we find that it immediately becomes cloudy from the deposition of urate of ammonia. This is no proof that it existed originally in that form. Urea is exceedingly liable to decomposition, and ammonia occurs as one of the products of it.

Besides, we are by no means certain that urea, which contains the elements of carbonic acid, ammonia, and water, instead of being an independent substance, does not in reality exist as a carbonate of ammonia in combination with water, or a hydrated carbonate of ammonia, so that on the latter being removed by evaporation, the uric acid immediately replaces the carbonic.

If we examine the various modes of treatment that at the present day are found to be of efficacy in this class of diseases, we cannot help remarking how readily they may all be explained by the increased oxydation of the uric acid; and it is found, that during an attack, the symptoms diminish just in proportion as the urea increases in the urine. It is in this way, that colchicum, which has long been looked upon as the sheet anchor in gout, is of efficacy. It is well known, that so long as this remedy does not act as a purgative, little benefit is experienced, but just in proportion as it produces free biliary evacuations does the patient undergo an amelioration of his symptoms.* A large amount of this biliary matter would have been converted into carbonic acid and water, and for this purpose a certain amount of oxygen would have been consumed, which under these circumstances acts directly upon the uric acid. Bloodletting, it may be urged, which always affords marked relief, would then be entirely contra-indicated, for this would diminish the amount of oxygen-carriers in the blood; but we must recollect that in both acute gout and rheumatism, a certain amount of local inflamma-

* In this we are supported by the opinion of Dr. Christison.

tion is present, and the abstraction of blood acts upon the inflammation alone, and has no tendency whatever to cut short an attack of either of these diseases. Again in regard to diet, we find that rich food and spirituous drinks, or in other words, oil and alcohol, are particularly proscribed. These, as we before explained, require more oxygen for their conversion than any other kinds of food, and in this way, diminish the amount supplied to the uric acid. Liebig has shown that muscle requires less oxygen for its conversion than even starch or sugar, so that it is by no means necessary to confine a patient labouring under these forms of disease to a farinaceous diet. Well-cooked meat, perfectly devoid of fat, will satisfy the appetite better, and fulfil more readily the pathological indications.

Of late years, above all other treatments the water-cure system has been found to be particularly applicable to these diseases in their chronic form. By this mode, the skin is made to eliminate its secretion to the fullest extent, so that nothing is retained which would abstract oxygen by its conversion. In regard to diet, both fat and alcohol are excluded, while, at the same time, a very great amount of exercise is taken in a pure and healthy atmosphere; and the individual, instead of being warmly clad, is constrained to wear very light clothing. All these means, as we have seen, merely act in supplying a large amount of oxygen to the uric acid; and these remarks are not so much in advocacy of the water-cure system generally, as to show the principles upon which its cure depends; and that these principles being understood, the treatment can

as well be administered to the patient at his own home, as in a place particularly provided for the purpose, in which he is apt to undergo the extremes of the system.

Dr. Gairdner, in an excellent work on gout lately published, in speaking of the efficacy of certain modes of treatment in this disease, has arrived at nearly the same results by close observation and long experience as have just been deduced from the application of chemical principles. He, however, does not take a chemical view of the action of these remedies, and it is exceedingly interesting to find the conclusions arrived at by an intelligent observer of facts, supported by results deduced from chemical phenomena. He has found that bloodletting, to say the least of it, is perfectly negative in its influence upon the disease itself, and only advises it to be practised to a small extent, merely to relieve the attendant congestion or inflammation; if pushed beyond this point it invariably does harm. He also recommends those purgatives which unload the bowels without producing serous discharges, and he has found his patients do much better when restricted to a diet composed of meat or an equal mixture of meat and vegetable food, than one composed of farinaceous articles alone. Of hydropathy he has had little or no experience, and speaks only of its effects from the representations of others.

Internal remedies, acting on nearly the same principles as those above adduced, are often found to be of great benefit. For instance, where the blood-globules are diminished, and a state of anæmia exists, a not uncommon con-

dition in those somewhat advanced in life, less oxygen is received, and iron in some of its forms will be found of decided advantage. Again, benefit will be obtained in many cases, by keeping the uric acid in solution by means of water and alkalies, or salts with alkaline bases. Benzoic acid,—which was supposed to have the property of converting uric into hippuric acid, an extremely soluble substance,—was proposed by Dr. Ure, and phosphate of soda by Liebig. In the last, the uric acid unites with the soda and forms urate of soda, while the phosphoric acid liberated, undergoes certain changes, during which, about half the uric acid is precipitated, the remainder being in solution with the soda. Dr. Thomas Buckler, of Baltimore, suggested, some four years since, the use of phosphate of ammonia in these cases, supposing it to act by producing double decomposition, and phosphate of soda and lithate of ammonia to be formed, both extremely soluble salts. This remedy has met with the most encouraging success, and although we are not convinced that the change takes place in the manner Dr. Buckler supposes, it is as yet the best means we are acquainted with for the elimination of the compounds of uric acid.

HIPPURIC ACID.

This acid requires about four hundred parts of its own weight of water for solution. It is entirely wanting in the carnivora, and corresponds in herbivorous animals to the uric acid in man. It has been found lately by Liebig to

be a normal constituent in the urine of the latter, and benzoic acid, when taken into the stomach, becomes changed into hippuric. The following formula shows how this may be effected.

	C	N	H	O		C	N	H	O		
3 atoms benzoic acid,	42		15	9		36	2	16	10	2 atoms	hippuric acid.
1 " urea, . . .	2	2	4	2	=	8			16	8 "	carbonic acid.
18 " oxygen, . .				18				3	3	3 "	water.
	44	2	19	29		44	2	19	29		

Dr. Ure proposed, as we have already stated, benzoic acid as a solvent for uric acid, under the impression that the latter substance became converted into hippuric, and for some time, this was the received opinion. But Professor Booth of Philadelphia, as well as others, deny this conversion, and state that the uric acid remains unchanged, while the benzoic alone undergoes any alteration. We have instituted upon ourselves some experiments in relation to this matter, and have taken one drachm of benzoic acid in twenty-four hours on two separate occasions, for the purpose of ascertaining the changes that the uric acid undergoes. The urine was examined both before and after each experiment. We ascertained that the uric acid in every specimen was present in almost exactly the same amount, while the hippuric, under the administration of benzoic acid became notably increased, and at the same time the urea underwent a slight diminution. These results agree in all particulars with those of Professor Booth, and prove that benzoic acid or its compounds can have no

effect in diminishing the amount of uric acid in the urine, or in the system at large.

From its extreme solubility it never occurs as a deposit, and has never been found as a constituent of any calculus yet examined. Its importance therefore in a therapeutical point of view is very small. Its physiology is by no means clearly understood, but as most articles of vegetable food contain benzoic acid in greater or less amount, this fact would account in great part, if not entirely, for its presence in the urine.

It has been found to be a very constant constituent of saccharine urine by Lehmann, Simon and others, and in a case recorded by Bouchardat, when the patient passed a large quantity of limpid urine containing albumen, and of a specific gravity of 1·007, this substance existed in large amount to the perfect exclusion of uric acid. It contains a larger percentage of carbon than any other organic principle with the exception of bile, and is thought by Bird to be one of the means by which carbon is eliminated from the system. And it may be, that there is some relation between the presence of this substance in the urine, and an excess or deficiency in the biliary secretion. An instance is on record of an hysterical girl, who, for many days took no nourishment but apples and water, and in whose urine a large amount of hippuric acid was present to the entire exclusion of the uric acid. Its ultimate composition is eighteen parts of carbon, one of nitrogen, eight of hydrogen, and five of oxygen, with one of water.

The following is a case of gout, in which the uric acid

was entirely replaced by hippuric, after the administration for some time of the benzoate of ammonia.

Case No. I., January 13th, 1849. —— ——, æt. 56, of sedentary habits, is of medium size and healthy appearance. He has lived freely until of late years, both in regard to eating and drinking, in the latter, using principally the light German wines. About eight years since he had his first attack of gout, which lasted for some weeks, and during the subsequent four or five years he had some half dozen similar attacks, which broke down his physical health to a very great degree. He now took a mixture of Iod. Ferri and Iod. potass for some months, under which treatment he recovered his strength in a great measure, but the paroxysms still recurred once or twice during the administration of the remedy. The different attacks have left tophaceous deposits about the small joints of his feet, and the last joint of the little finger. About a year since, he commenced using phosphate of ammonia, which he has continued up to within four weeks past. During this period there has been a recurrence of the disease two or three times, but the attacks were much milder than the preceding ones, and lasted but a few days. We regret that no examination of the urinary secretion was made during this period. In December last, the benzoate of ammonia was substituted for the phosphate. This remedy had been just then suggested by Dr. J. Buckler, under the idea that the uric acid would be converted by it into hippuric. Since the administration of these salts, although from cold or indiscretion in diet, there has been

occasionally some local inflammation set up around the parts where the cretaceous deposit existed, which lasted for a day or two, yet there has been no direct attack of the disease. In the latter part of December, about two weeks since, a specimen of his urine was examined with the following result:—Specific gravity 1·020, pale, without any deposit. The addition of hydrochloric acid throws down a copious deposit, which, under the microscope is found to consist of long, slender, rectangular crystals, some of them having the appearance of being spirally twisted. These are hippuric acid. Before adding the acid, some crystals of oxalate of lime in the form of double pyramids, were detected in considerable numbers. Urea, slightly deficient, uric acid almost entirely wanting. He was directed to take five drops of nitro-muriatic acid twice daily, and to discontinue the use of benzoate of ammonia. This he continued until the oxalate disappeared. A specimen of his urine voided to-day is as follows:—Specific gravity 1·022. The microscope discovers neither oxalate of lime, nor after the addition of hydrochloric acid any hippuric acid, which is replaced by uric. Urea and other ingredients in their usual proportions.

This case, unsatisfactory as its history is in some respects, has been reported from the interest it possesses in one or two points of view. Independently of showing the efficacy of phosphate of ammonia in gouty affections, so far at least as one case can go, it is interesting in showing how entirely the uric acid was replaced by hippuric during the administration of this salt (that it could not have been con-

verted into it, we have already shown), and also from the appearance of the oxalate of lime in the secretion, when the remedy had been carried too far, and this again quickly disappearing under appropriate means.

PHOSPHATES.

We have already stated that the inorganic elements of the urine were derived partly from the food taken into the system, and partly from the oxydation of the sulphur and phosphorus during the disintegration of the tissues. The combinations that all of these are capable of entering into are perfectly soluble, with the exception of the phosphates of lime and magnesia, so that the latter are the only ones requiring our attention. The physiological derivation of these substances, when compared with that of urea and uric acid, is very simple, but their modes of combination are less easily explained. In relation to this matter Liebig says, "In the flesh, blood, and other parts of animals, as well as in the grain of cereal and leguminous plants, no free alkali exists. The alkali which these substances contain is invariably combined with phosphoric acid; the acids formed in the vital process, namely sulphuric, hippuric, and uric acids, share the alkali among them, and this, of course, must give rise to the liberation of a certain amount of phosphoric acid, or what comes to the same thing, the formation of a certain amount of acid phosphates of soda lime and magnesia. The proportional amount of liberated phosphoric acid varies with the temperature; at a higher

temperature the phosphate of soda dissolves a larger amount of uric and hippuric acids than at a lower,—at one hundred degrees more than at sixty. It is owing to this, that urine sometimes on refrigeration, deposits uric acid or urate of soda, which of course can only take place by the uric acid, at a lower temperature, restoring to the phosphoric acid, the soda or potash, which at a higher temperature it had withdrawn from it. At the common temperatures phosphoric acid decomposes urate of soda, whilst at a higher temperature, uric acid decomposes phosphate of soda. When urine containing uric acid, and manifesting an acid reaction, forms no sediment on cooling, it shows that the amount of phosphoric and uric acids exactly balance each other in regard to their affinity for soda. Had there been a larger proportion of uric acid, this would have separated upon cooling; while on the other hand the presence of a preponderating proportion of phosphoric acid, would likewise have caused a precipitation of uric acid, because the affinity of the former for soda, would then exceed that of the latter." These remarks show the influence that these different ingredients exert over one another under varying circumstances, and to what degree the amount of uric acid and the temperature, influence the formation of the compounds of phosphoric acid.

The phosphate of lime, one of the salts previously mentioned, is, of course, formed by direct combination, but it is not clearly ascertained whether phosphoric acid and magnesia exist as a simple salt in the urine, or as a double one combined with ammonia, and called the triple phos-

phate. On adding ammonia to a specimen of urine, or when this substance is liberated by decomposition, the phosphates are immediately deposited. If the salt exists as a simple phosphate of magnesia, the deposition occurs because the additional base converts it into the triple phosphate, which is insoluble in water. But if it already exists as a double phosphate, as Bird supposes, and is held in solution by some of the acid compounds, the deposition then occurs from the neutralization of this acid. We have assumed heretofore, that ammonia does not exist as a normal constituent of healthy urine, or in an amount only sufficient to combine with the lactic and muriatic acids, and we are therefore of opinion that this salt exists as a simple phosphate of magnesia. If this were not the case, we could never find a deposit of the triple phosphate in any but alkaline urine, whereas it is occasionally present when the reaction is acid.

The sources of phosphoric acid being principally due to the quantity of this substance in the food, its compounds will of course vary in amount within wide limits under different circumstances, but so long as they remain in solution their quantity is of little importance. From various causes, however, interfering with the acidity of the urine, these salts become deposited, sometimes separately, but usually together, and their pathological importance is entirely dependent upon the cause which has produced this deposition. It is not at all necessary for an akaline condition of the urine to exist for this state of things to occur, but the acidity is usually very slight, and the specimen

soon becomes alkaline. As a general rule if a deposit already exists, the rapidity with which alkalinity takes place after emission is a measure of the severity of the disease. The stellated crystals are never found unless the urine is decidedly alkaline, but we have not usually observed them in the more advanced cases. Nor have we found them to indicate a severer lesion than the other form.

This diathesis is usually divided into a true and false. The first is, where from a general state of the system, or from taking large quantities of the carbonated alkalies, the urine becomes alkaline, or nearly so, and the phosphates are deposited. The other, is where decomposition takes place in the bladder, and is by far the most common of the two. All fluids containing organic substances have a tendency to resolve themselves into more primitive combinations, and this tendency is accelerated by warmth. Urea under these circumstances, gives off ammonia, and this change occurs more readily in summer than in winter, particularly if any amount of mucus be present, which acts upon the urine as a species of ferment. When the true diathesis is not due to the ingestion of alkalies, the cause of alkalinity is exceedingly obscure, but in all probability is owing to the excessive oxydation of those tissues which contain a large amount of phosphorus, as for instance the brain. Unless a deposit of phosphates can be accounted for by decomposition within the bladder, its presence is usually indicative of serious functional disturbance. Dr. Bence Jones found a deposit in the urine of persons labouring under acute affections of the brain either func-

tional or organic, with the exception of delirium tremens, and it has sometimes been observed in the old and infirm, or those who have received some blow or strain over the loins. Co-existent with the presence of this deposit under the circumstances just mentioned, there are always symptoms of a depressed state of nervous energy, but most frequently this exists rather as a cause of the disease, and not as a result.

From what has been said we can readily understand, that there is no specific or uniform plan of treatment that can be addressed to a patient labouring under this diathesis. Under the administration of acids the deposit will often disappear, but as the cause upon which it was dependent is still in existence, all that was done was but to mask an important symptom of the disease. When acids are used, however, tartaric, citric, and acetic, are said to be preferable to nitric or muriatic; for it has been found that the first pass through the circulation and make their appearance in the urine unchanged, while the latter have no tendency to render this secretion acid. But this is to be taken with some reservations; Dr. Wöhler ascertained that these vegetable acids, when taken into the stomach uncombined are found as such united with soda or potash in the urine, while if administered under the form of tartrates and citrates of potash or soda, they become converted into carbonates of their respective bases, and Pereira suggests the probability of the bile furnishing the basic matter for neutralizing these acids previous to their absorption. Neither the organic or inorganic acids have the property of rendering the urine acid, as both are found in that secre-

tion in the form of salts, and as tartaric and citric acids require a considerable amount of oxygen to convert them into carbonates, it is probable that the quantity of this substance taken into the system influences, in a great measure, their subsequent changes, while it cannot affect either the nitric or muriatic acids, and the therapeutical indications will therefore be more readily fulfilled by the administration of these latter. But the treatment in a majority of cases must be a general one, the particulars of which need not be entered into here. Dr. Rees advises the use of alkaline remedies, with a view of "acting upon the urine in such a manner as to render it less irritating to the lining mucous membrane, and thus prevent the secretion of that alkaline flux which has been pouring out in quantity." We have never seen the use of alkaline remedies in these cases attended with the benefit he ascribes to them, and it is obvious that this mode of treatment as in the other case, could do no more than mask an important symptom of some more obscure disease.

We stated in the previous chapter that the difference between the stellar and prismatic varieties of the triple phosphate which has been heretofore explained by assuming that the one is a monobasic, and the other a deutobasic salt, under the supposition that twice the quantity of ammonia was combined in the last in proportion to the other, is in reality due to the greater or less rapidity with which crystallization takes place. Our friend, Dr. David Stewart of this city, has lately called our attention to the fact that these crystals may be formed one from another

by simple aggregation. He succeeded in depositing them from the same specimen in both forms, and also in crystalline shapes intermediate between the two. This he effected by making an acid solution of the phosphate of ammonia and magnesia, and then adding very cautiously a drop of ammonia. This precipitates the phosphates immediately at the surface, a part of which, fall to the bottom of the glass to be again redissolved. The upper stratum is after a time gently shaken, when more crystals fall with the same effect. There is a point, however, if the solution is not too acid, or a sufficient quantity of ammonia has been added, when some of these crystals remain undissolved, and by carefully setting the tube aside at this stage, and allowing it to remain undisturbed for some time, we may detect by the microscope both the prismatic and stellar varieties with their intermediate stages. This experiment we have repeated, and are able to substantiate his opinion in regard to the mode in which these formations occur. Most of the stellar crystals are of two varieties, the first having four rays, and the second six. In the first we usually find, that during this process, by aggregation of crystalline material, two prisms are formed, which intersect each other at right angles; or else two of the arms which are in the same line become elongated, and material is gradually deposited in the interstices to make up a single perfect prism, the two long arms corresponding to the length, and the two short to the breadth of the crystal. In the second variety, where the figure has six rays, four of them become elongated in a similar manner, and the

same deposition occurs as in the other; or else these rays are all joined together at their extremities, and the figure then filled up, constitutes one variety of the prismatic crystal which is very frequently observed. In Fig. 10, some of these figures, illustrative of the change above alluded to, are copied from the field of the microscope.

Fig. 10.

CRYSTALS FORMED BY THE GRADUAL ADDITION OF AMMONIA TO AN ACID SOLUTION OF PHOSPHATE OF AMMONIA AND MAGNESIA.

1. Perfect prismatic crystals.
2. A complicated prismatic crystal, formed around a four-rayed stella.
3. A single crystal in the act of formation from two penniform crystals, which have crossed one another. These are joined at their extremities, and the crystal is observed to be formed by the addition of superimposed lamina.
4. Here a single prism is in the act of formation around two six-rayed stellæ lying side by side.
5. A complicated prismatic crystal forming around a large four-rayed stella.

These are all copied from the same field, the less distinct ones being omitted.

ALBUMEN.

Albumen is the first of the abnormal ingredients found in the urinary secretion, that we shall take into considera-

tion. The pathology of this substance and its relation to disease have been little understood until of late years, although the causes of its production are much more evident than of some of the substances we have just been considering. In what follows we shall endeavour to explain as clearly as possible its relations to the different abnormal conditions of the kidneys. Albumen is almost the only ingredient found in the urine that is, in reality, indicative of the state of the kidneys; and although in a certain proportion of cases, its presence in the urine has been heretofore explained by some assumed fault of secretion on the part of these organs, by which albumen is eliminated in the place of urea and uric acid, yet, inasmuch as the serum of the blood, and not albumen alone, is always found in the secretion in these cases, we shall endeavour to explain them by assuming, that whenever albumen is found in the urine, some obstruction to the circulation in the kidneys exists; and here, just as we see in a majority of effusions occurring in the serous and cellular tissues, the serum of the blood is poured out as a consequence of venous congestion.

Dr. Prout thinks that the presence of this substance in the urine is owing to four different causes; namely, a quiescent or inflamed state of the kidneys in a healthy condition, and a quiescent or inflamed state of these organs already altered by disease. In the first, a quiescent condition of the kidneys in a state of health, he supposes their "disorganizing function" to be temporarily suspended, so as to allow the albumen to pass off unchanged. In this

way, he thinks, the action of certain drugs, as mercury and cantharides, and also pregnancy, may produce this substance in the urine; and he infers that in individuals "liable to be so affected, there exists a sort of latent predisposition (incipient degeneration?) to kidney disorders." It seems to us, however, that the term he applies to this state of things, is scarcely an appropriate one. If the defect exists entirely in the kidneys, some physical change from a healthy condition must have taken place, and in a majority of instances this change, no doubt, is congestion. This is certainly the case in pregnancy, where the congestion is produced by the enlarged uterus pressing on the renal veins, and thus preventing the circulation of the return blood.

In connexion with the kidneys in a state of inflammation, which is the next division he makes, are described certain symptoms which would undoubtedly make their appearance if that condition existed; but acute inflammation of the kidneys is a rare disease, and most of the symptoms alluded to may be produced by severe congestion. The sudden repulsion of an exanthema or of an habitual discharge, is much oftener followed by simple congestion of the kidneys than acute inflammation as he supposes.

The close and accurate distinctions that he makes in relation to the other two divisions, it is needless to enter into here, as we shall speak of the effects of structural alteration of these organs further on.

Whatever be the remote cause affecting the physical condition of these organs, so as to produce albumen in the

urine, the immediate one is undoubtedly some obstruction of the circulation by which one or more of the elements of the blood escape from the blood-vessels, and pass out with the urinary secretion, either as pure blood, liquor sanguinis, or serum alone. These can readily be distinguished from one another, and as a general rule are a measure of the intensity of the disease. In granular degenerescence or Bright's disease, where the altered condition of the cortical portion acts as a mechanical obstruction to the circulation, we rarely find that pure blood is passed off unless there should be at the same time acute inflammation or congestion engrafted upon the previous disease; while in acute affections of these organs, it is rare for serum alone to be separated from the blood. We should also remark that the presence of blood may be owing to a lesion seated in any part of the urinary apparatus, as the bladder or urethra; but serum alone is always separated by the kidneys themselves. Chylous urine as described by Dr. Prout we have never seen, but it is undoubtedly due to the effusion of liquor sanguinis, and the coagulation of its fibrin.

It is thought that the function of the Malpighian bodies which are scattered throughout the cortical substance of the kidneys, is to eliminate the requisite amount of water from the blood, permitting the transudation of only enough fluid to dissolve the solid materials when there is no superfluity of water in the vessels, but suffering the escape of an almost unlimited amount of it when copious imbibition has allowed an unusual accumulation. Now as it is gene-

rally supposed that the granular degenerescence which takes place in Bright's disease is seated in these bodies, we can readily understand that their proper function being prevented, a less and less amount of water is taken from the blood, so that at last the superfluous quantity, holding a small portion of some of the solids of the blood in solution, is obliged to be deposited in one or the other of the textures in the form of dropsy ; and in consequence of the disorganized and obstructed condition of the glandular structure, the serum of the blood, with its albumen in solution, passes out, while the urea and uric acid are either checked, or secreted in diminished quantity, owing to the smaller extent of secreting tissue. In an individual labouring under this disease, the urea and uric acid are always diminished, and sometimes entirely wanting. But this deficiency, as we just stated, is owing to defective excretion, for the proportional excess still exists in the blood. The specific gravity usually falls very low, but bears a certain relation to the amount of urea and salts present.

It will be seen by what has been said above, that many causes are capable of producing albumen in the urine besides Bright's disease. Of these, by far the most common is congestion,* which may be owing to a variety of causes, such as pressure on the renal veins, stimulating diuretics, checked perspiration, &c. When, therefore, its presence is due to structural alteration of the kidneys, little can be

* From this cause, in Asiatic cholera, as well as in the more severe cases of ordinary cholera morbus, albumen is found in the urine.

accomplished by treatment; but if congestion alone be present, the condition is a perfectly curable one. The chief reliance is to be placed in bloodletting and revulsives; and of these, cupping over the loins and warm baths are decidedly the most efficacious. We have frequently seen individuals who, after a sudden check of perspiration or the retrocession of an acute exanthema, were suffering with scanty urine containing either albumen or blood, with frequent calls to micturate, pain over the loins, &c., be speedily relieved by the administration of warm baths and a few cups over the seat of pain; thus proving the existence of simple congestion of the kidneys.

OXALATE OF LIME.

From the similarity of the component elements of sugar and oxalic acid, Dr. Prout was led to the conclusion that the existence of these two substances in the urine was dependent upon nearly the same pathological conditions; and such was the received idea until Liebig suggested the greater probability of oxalic acid being formed by the oxydation of uric acid. Thus:—

	C	N	H	O		C	N	H	O	
1 atom uric acid . .	10	4	4	6	=	4	4	8	8	in 2 atoms of urea.
4 " water, . . .			4	4		6			9	3 " oxalic acid.
3 " oxygen, . .				3						
	10	4	8	13		10	4	8	13	

Oxalic acid, it is well known, unites with lime to the exclusion of any other acid with which it may be in com-

bination, and as a certain proportion of lime is present in all urine, we always find this acid existing in the form of oxalate of lime. We have never seen a specimen in which free oxalic acid or oxalate of ammonia existed, although such cases have been noticed by Simon; for in a large majority of instances, the lime is present in a greater proportion than is sufficient to enter into combination with this acid.

The changes that the manure called guano undergoes support the theory quoted above, in reference to the formation of this substance from uric acid. Guano is the excrement of sea-birds, and consists almost entirely of urate of ammonia. It is found that after exposing it to the atmosphere for some time, the uric acid is almost entirely replaced by oxalic, in the form of oxalate of ammonia. In these cases no urea is found, it having, in all probability, been decomposed into carbonic acid and ammonia. If, however, we wish to speculate upon these changes by numerical formulæ, it can be shown that it is not necessary that urea should be formed at all in the change of uric into oxalic acid, either in guano or in the human body. Thus:—

	C	N	H	O		C	N	H	O	
1 atom uric acid, . .	10	4	4	6			4	12		4 atoms ammonia.
8 " water, . . .			8	8		10			15	5 " oxalic acid.
1 " oxygen, . .				1	=					
	10	4	12	15		10	4	12	15	

And as it is exceedingly rare for oxalate of lime to be

present in urine without a deposit of urate of ammonia, it is not at all improbable that oxalic acid is really formed in this way, the ammonia thus produced uniting with uric acid, which is always present, to form urate of ammonia. In all probability, oxalic acid is never formed from sugar, for the changes that must take place for its conversion are exceedingly complicated (Turner), although it is possible that when oxalic acid is taken into the stomach, it may pass out by the kidneys as such.

From the fact that the elements of urea, with two atoms of water, are equivalent to one atom of oxalic acid, two of ammonia, and one of water, Golding Bird assumes that this substance is formed by the deoxydation of urea. He states, that under a depressing influence exerted on the nervous system at large, the urine undergoes decomposition very rapidly, and urea becomes resolved into carbonate of ammonia and water; but if a less depressing influence is supposed to be exerted, the decomposition is not carried so far, and oxalic acid and ammonia are formed. Now, in the first place, the formation of urea from uric acid is but little influenced by the nervous system; it is altogether due to the action of oxygen, after the influence of vitality has entirely ceased, and the substances from which they are formed are altogether under the influence of chemical laws. If these substances were not entirely without the influence of vitality, no change could have taken place, and we must therefore conclude that vital laws have but little to do

with the decomposition of urea into carbonate of ammonia, and still less into oxalic acid.

In speaking of the formation of urea from uric acid, we stated that we had examined the urinary secretion of a large number of convicts in the Maryland Penitentiary, with a view of ascertaining the influence of sedentary habits upon the formation of these substances. In twenty-four cases out of sixty that were examined, we detected oxalate of lime in minute crystals under the microscope, and instead of finding the urea increased in a large majority of the cases as Bird did, it was deficient in nine, normal in nine, and in excess in six only,—a proportion of one-third; while on the other hand the uric acid was deficient in seven cases and increased in seventeen. These proportions, it is true, are opposed to the theory laid down by Liebig in regard to the formation of this substance, by which there should be an increase of urea; but we have already shown that in two cases where the amount of oxygenation is the same, the relative proportions of uric acid and urea to one another will be very much influenced by the quantity and quality of the food, and we can readily understand that the same conditions will also affect the amount of these substances when oxalate of lime is present, although, all things being equal, if we adopt Liebig's formula, we will have the urea increased more frequently when this salt is present than under other circumstances.

The existence of oxalate of lime in individuals subjected to insufficient oxygenation, as just mentioned, in so large

a proportion, may also be alleged in support of the theory of its formation from uric acid, and as holding an intermediate place between this substance and urea; but we should remark, that in none of the cases alluded to were the symptoms produced by its presence of sufficient importance to subject the individuals to treatment. In every instance the crystals were in the form of double pyramids, and exceedingly minute in size; and additional causes, such as disorder of the digestive organs, are requisite to produce crystals of a larger size with a corresponding increase of intensity in the symptoms. It has been already noticed that oxalate of lime is often found in the urine of persons labouring under spermatorrhœa. In the institution above mentioned, as in all others of a similar character, onanism is an exceedingly common vice, and although the same fact was observed in the convicts there confined, we are under the impression that there is no relation between the two, more than that the habits of those addicted to this mode of sensual gratification, under any circumstances, are nearly always sedentary, and consequently a less amount of oxygen would be respired than if they were engaged in more active pursuits.

The difference in form between the stellated and prismatic crystals of the triple phosphate has been already explained, as being due to the greater or less rapidity with which crystallization takes place; but the many varieties of oxalate of lime that are to be observed under the microscope cannot always be thus easily accounted

for. The following remarks however, will we think, throw some light upon it.

If oxalic acid and lime in solution be added together, the crystals formed under these circumstances are always double pyramids, and however long the deposit be allowed to remain, neither dumb bells or ovals are ever found to make their appearance. Whereas, if a deposit consisting entirely of uric acid be carefully and repeatedly washed, and clear water added, we may discover in a certain number of cases, after a time, that dumb bells are present, indicating beyond a doubt their formation in some instances from uric acid alone. We have, in several instances, been able to verify this fact by observing the changes actually taking place. By setting aside several specimens of uric acid thus obtained, and noting these changes from day to day, we observed that in the first place the rectangular crystals had a tendency to become irregularly rounded off at the ends, afterwards to be fissured across near their centres in an oblique direction, and finally these two portions, still adherent, became rounded off in irregular steps towards the periphery of the figure, and this change has been remarked not only once, but on several different occasions. Should the crystals consist of rhomboids rounded off at their oblique angles, we may often observe that these first unite at their points, the two longitudinal axes being both in the same line, and then by the extreme points falling off, and these becoming by degrees irregularly rounded, constitute a variety of the dumb bell crystals, in which the convexity

of the sides is but slightly marked. Another, and perhaps the most common form of this transition stage, is where one end of the ball is fully formed, as is also the union between the two, but the opposite head, instead of being rounded, is elongated to a point. More commonly they are very irregular in shape, but still with resemblance enough to a dumb bell to be sufficiently characteristic. The figures marked 4, in Fig. 7, which is illustrative of this change, are of this variety. It is rare for more than one or two of the crystals, while actually in the transition stage, to present themselves at the same time under the field of the microscope. But within a few months past, we have been fortunate enough to detect in a specimen of uric acid put aside for this purpose, not only the dumb bells in their formative stage, but also several fully formed, as well as some uric acid almost unchanged. This we copied from the field of the microscope, and is the plate spoken of above. The depression at the side of the dumb bell does not always completely encircle it, as it appears to do when viewed under the microscope, for on making it revolve a quarter of a circle on its own axis, by the addition of a drop of alcohol or ether, it is ascertained to be an oval with an elevation at either end, and just as the view alternates between these two positions do we obtain an appearance approximating at one time to an oval, and at another to a dumb bell.

In Fig. 2, (5,) a uric acid crystal of an oval form is represented, which on comparison will be found to resemble very much some of the oval figures included

under the head of oxalate of lime. In two or three deposits consisting principally of oxalate of lime in double pyramids, intermixed with the oval figures above described, we have remarked these latter changing into dumb bells. This change took place as follows:—in the first place, some of the ovals would be crossed by two diagonals meeting at the centre of the figure, in another, a part of the space included between the two diagonals on one side had separated from the rest, leaving a figure bearing a marked resemblance to a kidney bean, and in a third, the same separation had occurred on both sides, leaving an irregular-shaped dumb bell, which at another part of the field had become perfectly formed. In Fig. 7, (7,) we have endeavoured to represent this change.

All these various forms above alluded to, and represented in Fig. 6, have been arranged by previous observers under the head of oxalate of lime, and although we have followed their example, we are not entirely convinced that this reference is a correct one. We are not acquainted as yet with the chemical changes that the uric acid undergoes in the formation of the above-mentioned bodies, but we do know, that there is no lime entering into their composition, that they are rarely present at the time the urine is voided, and as we have no proof that uric acid abstracts oxygen from the water, the only change that can take place when it is allowed to remain for some time in pure water, it seems more reasonable to suppose that the dumb bells at least owe their origin, in a majority of cases, to the disintegration of the uric acid, or it may be, that

they are some intermediate stage between this substance and oxalic acid.*

Fig. 7.

CHANGE FROM URIC ACID INTO DUMB BELLS.

1. Crystals of uric acid in the act of breaking in half by disintegration.
2. Two perfect crystals of uric acid united at one extremity preparatory to the others falling off.
3. Same as preceding, except one end has become one of the balls of the dumb bell.
4. These are irregularly-formed dumb bells, found in another specimen of uric acid allowed to stand for a few days.
5. Crystals of uric acid just commencing to disintegrate.
6. Fully-formed dumb bells.
7. Dumb bells formed from ovals.

A theory founded exclusively upon the deficient oxydation of uric acid cannot account satisfactorily in all instances for the existence of this salt in the urine. If its

* Dr. Golding Bird, a short time since in a conversation with Dr. Power, of Baltimore, stated that he had ascertained them to be oxaluret of lime.

presence were entirely due to this cause, we ought to be enabled to produce it at will in any individual subjected to insufficient exercise, or whose food contains a large amount of carbonaceous matter. But this is not the case; it is rarely found in those persons whose digestive organs are perfectly healthy, and as a general rule the larger the crystals, the greater is the amount of functional disturbance in these organs. It is in reality derived from two sources, both referable to deficient oxygenation. We have already explained its pathology in relation to one of these sources, namely, the uric acid, and in many cases the fault is seated in defective transformation of this substance alone. Nearly all the cases referred to in the Maryland Penitentiary are of this class, and these persons cannot be said to be labouring under an oxalate of lime diathesis; for the presence of this salt in the urine under these circumstances rarely gives rise to any inconvenience, and is not necessarily accompanied by disorder of the digestive organs. The other source from which oxalic acid is derived, and by far the most important, is mal-assimilation in primary digestion.

In the first place, according to Turner, when carbon unites with oxygen to form carbonic acid, it always passes through the intermediate stage of carbonous or oxalic acid, and if the requisite amount of oxygen be withheld the conversion goes no further. Now one of the products of primary digestion is lactic acid, and the carbon of this substance in a healthy individual is eliminated in the form of carbonic acid. But as it has to pass through the stage of carbonous acid, a deficient supply of oxygen allows it to remain as

such, and instead of the lungs eliminating carbonic acid, the kidneys excrete oxalic. If to a healthy individual we administer small and repeated doses of oxalic acid, we find that its effect is to produce derangement of the digestive organs, and great depression of the vital forces. Exactly the same symptoms ensue, if instead of taking oxalic acid, the patient takes into his stomach those substances whose conversion produces it.

Oxalate of lime is the most common crystalline deposit met with in the urinary secretion, but as we have just stated cannot always be considered as indicative of a morbid state, and as such demanding an appropriate treatment. Of the different forms, the double pyramid is by far the most common, and we have rarely met with the dumb bells ready formed at the time of micturition, although they became apparent soon afterwards. Some of these pyramids are so exceedingly minute, that they can only be detected after close observation, and with a very strong light, while others again, under a power of two hundred and fifty diameters, present an apparent base of nearly half an inch; these latter, however, are very rare. The symptoms coexistent with the condition of urine are very variable. At times, the deviation from health is so little marked that the patient scarcely complains; while in the more severe cases he is totally unfitted for either mental or physical exertion. We may always suspect its existence when the patient complains of an habitual inability for mental or physical exertion, with a distaste for society, and all those symptoms usually included under the head of hypochon-

driasis; at the same time, that he is not labouring under seminal emissions, or any local cause to account for his condition. Coexistent with these, there is usually some trouble about his nervous system, particularly neuralgia, and almost always some functional disturbance of the digestive organs.

The general indications of treatment are in some respects similar to those of uric acid. It is almost impossible by any system of diet to avoid taking lime into the circulation, and our attention must therefore be directed to prevent the formation of the oxalic acid. By free exercise, and attention to the functions of the skin, the more complete oxydation of the uric acid primarily formed, will be effected; but inasmuch as the digestive organs are always more or less deranged, particular attention must be paid to the proper performance of their functions. It is seldom, however, that the oxalate is gotten rid of by these means alone, but we have fortunately a valuable remedy in the nitro-muriatic acid, under the use of which, it soon disappears. There are few cases that are not quickly relieved, if not entirely cured by this acid. Its mode of action is twofold: in the first place, by means of its oxydizing power it supplies oxygen to the lactic acid in greater quantity, and thus allows the carbonous acid to be converted into carbonic; and it also acts immediately upon the stomach, and by giving tone and vigour to the digestive functions, neutralizes the poisonous effects of the oxalic acid upon these organs. It is usually given in doses of a few drops three or four times daily in some

bitter infusion. One of the best is gentian, and should this disagree, an infusion of hops may be substituted with advantage.

The following case of the oxalate of lime diathesis, well marked both in regard to symptoms and the effects of treatment, is interesting from the fact of the patient's urine illustrating the change from ovals into dumb bells already spoken of, and also from the secretion containing iron in an appreciable quantity.

Case II., March 23d, 1850. George E——, æt. 26, a German of medium size, light complexion, and somewhat anæmic in appearance, entered the Penitentiary three weeks since. He has been at very light work since his entrance, but came to the hospital to-day, stating that he was totally unable to make any physical exertion. He complains of pain in his head and back, and weakness about the lower extremities, and has slight cough produced by enlargement of his tonsils.

March 24th. Lies drawn up in bed, says he is unable to get up. Has not slept at all for some nights, bowels regular, no fever, skin moist and clammy to the touch. Cries and sobs like a child when any question is addressed to him, but says he cannot tell why. Is not emaciated, but his skin has a doughy appearance, and all his tissues are very pale. Lungs and heart sound. Suspecting him of masturbation, he declares that he has no venereal desire, nor has he had any for four years; that he never practised onanism, nor has he ever had seminal emissions. His appetite is bad, and most articles of food produce

some uneasiness for a short time after eating. Ordered mur. tinc. ferri, and strychnine, each three times daily.

April 19th.—Patient's condition has not improved much since last note. His tissues are not so pale, and his appetite is better. Various remedies have been administered with little or no success. The trouble about his nervous system is still as marked as it was at entrance. He complains greatly of pain over the loins and neuralgia, the last particularly after meals, and is so weak and has so little control over his lower extremities that he staggers when attempting to walk. An average specimen of his urine was examined to-day with the following result. Colour natural, slight filmy deposit on standing, reaction acid, specific gravity 1·022, passes twenty-four pints daily. Uric acid and urea both deficient. Under the microscope the sediment is found to consist of various substances, in which oxalate of lime predominates. There are a few irregularly-formed crystals of uric acid intermixed with urate of ammonia, a large quantity of epithelium scales, and a few amorphous shreds of mucus. The crystalline portion of the deposit is made up of octohedra, ovals, and dumb bells. These octohedra are very variable in size, some being almost as minute as the amorphous grains of urate of ammonia, while a few present an apparent base of three-quarters of an inch, and are beautifully bevelled along the edges. These are the largest crystals of this salt we have ever seen. The ovals are variously modified; some are merely crossed by two diagonal lines, in others a part of the space included between the two diagonals on

one side, has separated from the rest of the figure, while a third presents the appearance of a fully formed dumb bell surrounded by an oval. They are well represented in Fig. 7, (7.) On adding liquor potassæ to a small quantity of this man's urine, after it had been standing twenty-four hours, it immediately became a dark claret colour, which increased by boiling. Knowing that it could not contain sugar, the precipitate was tested with the yellow prussiate of potash, when it gave the well-marked Prussian-blue colour, indicative of the presence of iron.

He was ordered five drops of nitro-muriatic acid, three times daily, in an infusion of gentian and hops.

April 27th. He has been taking the acid eight days. Strength somewhat improved, and he sleeps well at night. On examining a specimen of his urine which had been standing for twelve hours, we found that it had become alkaline. Specific gravity, 1·020. Colour deep brown and slightly cloudy. Both urea and uric acid very deficient. Under the microscope crystals of oxalate of lime are still perceptible, but they are all octohedra, and of a much smaller size. Mixed with them are some prisms of the triple phosphate, while the oval figures and the dumb bells have entirely disappeared.

May 20. This man improved very rapidly after the last date, and was sent to work on the ninth. Although still somewhat anæmic, his appearance is more indicative of health, and his step firmer. His appetite has improved, and he rests well at night. He has no longer any pain

over the loins, and the feeling of malaise is fast disappearing. He works well all day at light work without any complaint. Ordered to discontinue the acid. His urine is as follows:—specific gravity, 1·023, uric acid somewhat in excess, urea deficient; no appearance of any importance under the microscope.

The two following cases were reported with some others last year in the American Journal of Medical Sciences, and being well marked, are inserted here as illustrative of the symptoms and treatment of the disease.

Case III., January 27th, 1848. *Ashby Carter*, a mulatto, æt. 42, a barber by trade, is married and has a family. He is very tall and a good deal emaciated, and says that he has not been well for eight or ten years, suffering principally from muscular debility. During this time he has had occasional attacks of what he calls dyspepsia, which obliged him to discontinue work for periods of one to three weeks. He says that he never noticed any peculiarity about his urine, nor has he had any pains over the loins. Since last November he has been getting gradually worse, and has now been confined to his room for two weeks. His countenance is sunken and expression of face anxious. Has considerable cough and pain in different regions of the chest, but no physical signs indicative of disease. He suffers greatly from neuralgia of the superior branch of the fifth pair of nerves, which has been latterly almost constantly present. There is great muscular debility, restlessness, and incapacity for mental exertion. Tongue moist and natural,

but the papillæ are much enlarged and reddened; at the root of this organ some of them are as large as duck shot. Appetite good, but most articles of food produce uneasiness after eating; bowels usually tympanitic and habitually constipated. There is slight pain over the loins, and almost constant irritability of the bladder, obliging him to rise three or four times during the night. A specimen of his urine was as follows:—appearance natural, specific gravity 1·031; on holding it to the light a slight cloud is perceptible; uric acid and phosphates normal, urea deficient; a drop placed under the microscope reveals an unusual quantity of epithelium scales, and a few crystals of uric acid. Supposing from the large quantity of epithelium scales present that oxalate of lime might exist, it was examined attentively, but no crystals could be discovered. The patient was then directed to collect all that he passed during the subsequent twenty-four hours, and on examining a drop of this, large quantities of the oxalate were found. The shape of these were double pyramids of different sizes, the bases varying in appearance from one-eighth of a line to three lines in length. Ordered counter-irritation to the stomach with farinaceous diet, and ox. argenti half a grain, with fel bovis grains iij. three times daily.

February 2d. Patient's condition somewhat improved; his food agrees better with him, and his bowels are regular. Urine remains the same. Ordered to take, in addition, nitro-muriatic acid in an infusion of gentian.

February 10th. The acid disagreed so much that he

was obliged to discontinue its use after a few doses. His tongue now looks better, but he still feels very weak. Ordered some animal food, and substituted an infusion of hops for the gentian. Urine still contains the same amount of oxalate of lime.

March 2d. Patient expresses himself as greatly better, and he has been out of doors for the last week. Bowels regular, appetite good, and no sense of uneasiness after eating. The neuralgic pains have much improved, and he has less irritability of the bladder. Papillæ on the tongue much enlarged. Ordered to stop the ox. silver and fel bovis, and go on with the acid twice daily.

April 4th. Patient has been improving fast since the last note. He has gained flesh, he has returned to his usual occupation, and suffers no longer from neuralgia. His urine is as follows: uric acid slightly in excess, phosphates deficient. A few isolated crystals of oxalate of lime, with an occasional one of the triple phosphate, are perceptible under the field of the microscope.

Case IV., February 22d, 1848. —— ——, æt. 36, and a lawyer by profession. His attack commenced about four months since, and he has been gradually getting worse. After being subjected for some time to the influence of moral causes which tended to depress his nervous system, he found that his digestion had become impaired, that he had acquired a distaste for society, and was incapable of either mental or physical exertion. About two weeks since, in addition to these symptoms, he found himself seized with attacks of vertigo and great muscular debility,

so violent at times that he would fall down suddenly, and require assistance to reach his home. This last symptom has increased so much within a few days past, that he is now unable to leave the house. At present his condition is as follows: countenance pale and sallow; skin moist, cold, and clammy; tongue slightly furred; complete anorexia and constipation; vertigo on the slightest exertion; pulse weak, otherwise natural; pain over the loins, and along the course of the urethra, particularly in urinating; great confusion of thought, and depression of spirits; perfect inability to apply his mind to even the ordinary affairs of every-day life, and extreme despondency. An examination of a specimen of his urine gave the following result: colour deep red, specific gravity not ascertained; large and copious yellowish-white deposit at the bottom of the glass, which clears up on heating it, and consists of urate of ammonia. On examining a drop of the lowermost strata under the microscope, numerous crystals of oxalate of lime are perceptible, of different shapes. The most abundant are of two different kinds; the one being very small, double pyramids, with square bases, and the other flat ovals, from two to three lines in length, of a black colour with the exception of a small transparent square in the middle. There are also some pyramids of a larger size, and a few dumb bells, the latter being less concave at the sides than those figured by Golding Bird in his work on urinary diseases. In addition to the oxalate, there are observable large quantities of epithelium scales, and a few grains of uric acid. The phosphates are deposited in the usual

quantity on the addition of ammonia, and the urea and uric acid are very nearly normal. Ordered a few doses of mass. hydrarg., with iron and quinine.

February 25th. Symptoms nearly the same; ordered nitro-muriatic acid, with chamomile tea, three times daily.

March 13. Has been improving steadily since he commenced the use of the acid. Is walking about, and says he thinks he will now get well. A specimen of his urine is as follows: urea and uric acid nearly normal; some very minute crystals in the form of pyramids, and a few dumb bells, such as have been previously described, are observable, the whole quantity being very much less than in the specimen first examined.

March 21st. Says he is perfectly well. Skin and colour natural, no oxalate in the urine, but a few crystals of the triple phosphate are to be seen.

DIABETES OR SACCHARINE URINE.

After having discussed in full the pathology of uric acid and oxalate of lime, and shown how readily their formation and pathological relations are to be explained by the influence of chemical laws upon devitalized matter, we come next to the consideration of that abnormal condition which is included under the head of renal diseases, and is characterized by the presence of a certain amount of sugar in the urine. Here, however, the results are less satisfactory. We know that the kidneys are in no way concerned in the production of this substance, and merely act in eli-

minating a material which can subserve none of the purposes of the economy, and that the production of the sugar is, in reality, due to some fault in primary assimilation; but inasmuch as the different stages in healthy digestion are as yet far from being clearly understood, it is not to be wondered at, that many of the abnormal processes of this function should still be involved in obscurity, and among them the pathology of the disease under consideration.

The term diabetes, was formerly applied to all disorders characterized by the discharge of an increased quantity of urine, but it is now strictly confined to those affections in which this secretion contains a greater or less amount of sugar.

In a healthy individual all the saccharine and amylaceous substances taken into the stomach are expended in the respiratory process, and pass out as carbonic acid and water. But in diabetes only a small portion, if any of these substances are eliminated in this form, they having passed into the circulation as sugar, and being then unfitted for respiration, while at the same time the sugar can take no part in nutrition, it becomes the function of the kidneys to abstract it from the blood and eliminate it from the system. Its presence in the blood in diabetes, as well as in the fæces and perspiration has been proved by numerous observers, although occasionally analyses made by able chemists have failed to detect it. But this failure may be easily explained. Its existence in the circulating fluid is entirely dependent upon the ingestion of saccha-

rine and amylaceous substances, and if these be withheld or a sufficient period is allowed to elapse for the kidneys to abstract all the sugar from the blood, it would, of course, be imposible to detect it in that fluid, if the analyses were performed at that time only.

A number of experiments were made by Professor Graham, on diabetic patients in University College Hospital, the results of which, have been published by Dr. Walshe in an article on "Morbid Products" in the Cyclopædia of Anatomy and Physiology. They embody some very interesting facts, and are calculated to throw considerable light upon this obscure affection. He says:

"The quantity of saccharine matter found in the urine, never exceeded the starch and sugar in the food. On the other hand, the sugar and starch in the food were accounted for in the urine, to within one-fourth or one-fifth of the whole quantity. As there was also sugar besides in the fæces in a sensible, although not considerable quantity, it appeared to follow that sugar and substances convertible in the stomach into sugar, are in diabetic patients, nearly, if not entirely indigestible; that is, they pass through the blood without being burned and thrown off in the form of carbonic acid and water, as they are in a healthy state. The idea of any portion of the saccharine matter found in the urine being formed from the protein or azotized portion of the food was entirely excluded.

"The proportion of sugar in the urine has a limit which it cannot exceed, but which varies within a small range in different patients, about four and a half per cent. being

the usual maximum. The volume of the urine comes, therefore, to be entirely governed by the quantity of saccharine matter in the food.

"Although sugar escapes oxydation in the respiratory process of diabetic patients, alcohol is entirely consumed. On one occasion, a diabetic patient swallowed twelve ounces of absolute alcohol contained in a quart of whiskey, within twenty-four hours, without a trace of it appearing in his urine or other excretions. Gum arabic, also, taken as food to the extent of five or six ounces a day, did not cause an increase of sugar in the urine, and was, probably, therefore digested. Both alcohol and gum are like sugar, pure aliments of respiration."

These facts, point to the relation between diabetes and an abnormal digestion of the amylaceous and saccharine substances contained in the food; but, as yet, nothing has been said in regard to the ultimate pathology of this affection. The two explanations which at present attract the most consideration are those of M. Bouchardat and of M. Mialhe, both of which, we shall endeavour to explain. Bouchardat thinks that the conversion of starch into sugar is effected by some substance existing in the gastric juice found in the stomach of diabetic patients alone, and that this substance has upon the amylaceous articles of food, the same action that diastase has upon barley which is in the act of germinating. This principle he has isolated by extracting it from the matters vomited by a diabetic patient, a few hours after a meal, and he states, that it has the same properties, and is capable of effecting the same

changes as that extracted from barley. He considers it as a pathological product, and affirms that he never saw it in any one who was not labouring under the disease in question. He also thinks that the sugar thus formed is derived from the amylaceous and saccharine element of the food alone, and that the protein compounds perform no part in its production. This is undoubtedly true, for the quantity of saccharine matter in the urine is always in direct proportion to the amount of starch and sugar contained in the food, for if these are diminished, both the sugar in the urine and the amount of water undergo a diminution, and if they are entirely withheld, the secretion returns to nearly its normal properties. In addition to this, M. Bouchardat states the additional fact, that the thirst is in direct proportion to the sugar and starch taken in as food. Thus, for each ounce of these substances, the patient usually drinks seven ounces of water, and passes nearly eight ounces of urine; that is to say, the quantity of water an individual labouring under diabetes requires to digest the starch he takes in, is exactly equal to that which must be added to a certain amount of diastase to convert starch into sugar.

There are many physiologists, however, who contend that this conversion of starch into sugar is not a pathological process, but on the contrary, that bread and other substances containing starch all undergo this transformation normally, without which they cannot be absorbed. But if this is the case, we may ask what becomes of this sugar in a healthy individual, and why is it that it only

makes its appearance in the urine of certain individuals? M. Bouchardat, foreseeing this objection, gives an additional explanation as follows. He says that this is accounted for by the different manner in which these substances undergo their transformation in the digestive process in the two cases. In a healthy man the amylaceous and saccharine materials of the food are scarcely attacked in the stomach, and do not undergo the transformation into sugar until the addition of the pancreatic juice. For if an individual in a state of health be forced to throw off the contents of his stomach a few hours after a full meal of amylaceous substances, we will find it to contain the merest traces of sugar. This change takes place after the addition of the pancreatic secretion, and the new product is then absorbed, but does not enter into the general circulation until it has been carried by the hepatic vessels through the liver, so that its entrance into the general torrent is gradually accomplished, and the saccharine matter is eliminated in its proper form by degrees. In a diabetic patient, on the contrary, by the aid of the diastase which exists in the stomach, all the amylaceous articles of food are changed into sugar while they are still in that organ. This sugar then passes quickly into the blood, and if it exists in an amount sufficiently large it undergoes no change, but is eliminated as such by the kidneys.

The recent experiments of Bernard, who proves that sugar exists in an appreciable quantity in the substance of a healthy liver, and that the use of the pancreatic

secretion is to digest the non-nitrogenized elements of the food, go far to substantiate this ingenious theory of M. Bouchardat.

The other explanation of the pathology of diabetes spoken of previously is as follows. M. Mialhe thinks that diastase exists normally in the saliva, and that all the starch taken in as food undergoes the conversion into sugar by the aid of this secretion. He even thinks that this transformation is more easily effected in a healthy man than in one labouring under diabetes, because the first secretes a greater amount of saliva. He then goes on to explain the presence of sugar in the one and its absence in the other, by stating that the blood in this disease is either neutral or acid, and that consequently the sugar after it is absorbed into the circulation does not undergo any further transformation, as it does when this fluid is alkaline, and being a foreign body is as a consequence eliminated by the kidneys. He accounts for this neutral or acid state of the blood by the suppression or diminution of the cutaneous transpiration, by which an unusual amount of lactic acid is retained in the circulation, thereby rendering it acid; and he also thinks that the abuse of acids as articles of food may have the same effect. He admits that the blood in diabetes is sometimes alkaline, but says that the degree of alkalinity is so slight that it is insufficient to transform all the sugar which has been absorbed, a portion of it therefore must be eliminated by the kidneys.

Now this explanation, ingenious as it is, rests almost

entirely upon the basis of theory. It has by no means been proved that the reaction of the blood in diabetes is either neutral or acid, and moreover, the suppression of the cutaneous exhalation, which he looks upon as the immediate cause of the disease, is more probably an effect, and due to the excessive action of the kidneys; for so large an amount of water is necessary to dissolve the sugar in the urine, that only a very small quantity remains to be passed off by the skin. The theory, therefore, offered by Bouchardat seems as yet to be the most tenable, for although more complicated than that suggested by M. Mialhe, it is nevertheless supported by a greater number of probabilities.

Diabetes is almost always a chronic disease, and during its course the urine is often observed to contain albumen or even blood. This, we think, is due not to any vitiated secretion on the part of the kidneys, but to simple congestion of their secreting portion. The abnormal function that these organs are performing necessitates a greater afflux of blood to them, and in a majority of cases of this disease we find that they are congested and sometimes hypertrophied. When this condition is carried a little farther, we can readily understand how albumen may make its appearance in the urine, as we have already explained in speaking of the pathology of that substance.

The quantity of urea and uric acid, as well as the inorganic elements, are all diminished in the urine of an individual labouring under diabetes; but this diminution is a relative one only, for if all the urine passed in twenty-

four hours be collected and examined for these substances, they will be found in their usual proportions.

There are two prominent symptoms always connected with this disease if it has progressed to any extent, namely, emaciation and thirst. The first is owing to the fact that all the saccharine and amylaceous articles of food which in a healthy individual subserve the purposes of respiration, pass off by the kidneys as sugar, and consequently a large proportion of the carbon and hydrogen of the azotized materials has to be expended for this purpose. While the necessity for a large amount of water which the sugar requires for its solution, is intimated to the system in the same way that thirst is experienced in a healthy man wherever there is a deficient quantity of fluid in his blood, and we find that the thirst in diabetes is in direct proportion to the quantity of saccharine and amylaceous articles of food ingested.

The main indication of treatment in this disease is to withhold from the patient those articles of food which contain sugar, or are capable of being converted into it. Animal food fulfils this condition perfectly, but it is found that few patients are able to bear this exclusive diet for any length of time. Within a few years past, M. Bouchardat has proposed the use of bread made almost exclusively from gluten, to which is added a sixth part only of starch. This satisfies the appetite sufficiently, and by its use, in conjunction with a meat diet, the sugar is often found to disappear entirely from the urine, the thirst to diminish, and the patient to improve in appearance, and

if long enough continued, he may return to a state of health, but this is rare. M. Mialhe recommends strongly the use of alkaline remedies, in accordance with his theory of the disease just mentioned, and to these may be added a host of others. But these means can do little more than act as mere palliatives, or at the most remove the effects, while the cause still continues to exist.

CHAPTER VI.

ON THE ANALYSIS OF CALCULI.

When a urinary sediment is retained for any length of time in the bladder it frequently produces a calculus. These calculi are consequently composed of nearly all the constituents that are found in the urinary secretion, and whose pathology we have just been considering. They are made up of separate layers formed round a nucleus, which consists either of some sediment retained in the bladder, or is sometimes a foreign body introduced from without. It is not usual for a calculus to be made up of one substance alone, for in the course of its formation it frequently produces irritation of the bladder and alkalinity of the urine, by which the phosphates are deposited, or the urates, if they are held in solution by an insufficient quantity of water. They vary in size from a pea to a hen's egg and upwards, and there may be but one, or more than a hundred in the same bladder. Their colour varies according to the substances of which they are composed, and may be either white, gray, yellow, or brown. Their shape is usually oval, and their surfaces may be either perfectly smooth or very rough. The oxalate of lime

calculi are the most irregular in shape. This salt is perfectly insoluble in the urine, and it therefore passes into the bladder in a state of suspension. If a nucleus is present, it attaches itself to it in the form of an irregular mass, so as to bear some rememblance to a mulberry, from which circumstance it is usually called the mulberry calculus. It is not sufficient that a portion of the external layer only should be examined; the stone should be sawed through with a fine saw, and if necessary polished. In this way the appearance of the different layers is perceptible, and if they differ much an analysis of each, as well as of the nucleus, should be made.

It is not our intention to go into a lengthened detail of the analysis of every substance that has been found up to the present day a constituent of urinary calculi, but shall speak only of those that have been most commonly observed, for it is presumed that the student who wishes to examine this subject in all its various details will have already mastered all the information which we purposed at the commencement to convey in this work.

The appearances these different substances present are as follows:—

1. *Uric Acid.*—This is the most common constituent of urinary calculi. They are of every possible size, and their colour is generally yellow, rose-coloured, or brown, but sometimes white. Their surface is smooth, and at times even polished. Their fractured surface either crystalline or composed of dense, concentric laminæ merging into each other. They are never pure, being always

mixed with colouring matter, frequently with alkaline urates, and sometimes small quantities of earthy phosphates.

2. *Urate of Ammonia.*—These are very rare, and more common in children than adults. They are usually small, and of a whitish or clay colour, with a smooth or tuberculated surface, and an earthy fracture, exhibiting concentric layers.

3. *Uric Oxide.*—But a few of these calculi have as yet been observed. They are always nearly pure. Their external surface is smooth and polished, and of a cinnamon-brown colour. The lamina are easily separated, and in point of consistence they resemble uric acid.

4. *Cystin.*—Although calculi of this substance are by no means common, yet they have been found more frequently than those of uric oxide. Generally they constitute the whole calculus, and are usually small, round, smooth, and of a yellow colour. Their consistence is soft, and internally the crystalline appearance is not well marked.

5. *Oxalate of Lime.*—Next to uric acid and earthy phosphates these calculi are the most common. Their form is peculiar, being usually round, and studded with elevations, which are sometimes sharp and angular. Some are as small as a hemp-seed, while others are as large as a pigeon's egg. Their colour is white, bright yellow, yellowish-brown, or dark green. The largest are generally the darkest. They are very hard and finely gra-

nular, and their consistence alone is sufficient to distinguish them from any other calculi.

6. *Ammoniaco-Magnesian Phosphate and Phosphate of Lime*, or, as it is sometimes called, fusible calculus. These are of the most common occurrence next to uric acid. They are white, gray, or dark yellow. Usually round and very friable, although occasionally quite firm in consistence. They do not often occur in laminæ, but when they do, and the divisions between them are well marked, numerous shining crystals are often observed.

7. *Phosphate of Lime.*—These are very rare; their surface is a pale brown, and looks as if it were polished. The laminæ are very regular but easily separable, and each lamina is striated in a direction perpendicular to the surface.

When a calculus is presented for examination, the first step after noticing its external qualities, is to ascertain the changes that take place under the blow-pipe. The application of this instrument for the present purpose is easily acquired, and a very small portion of the calculus, about the size of a mustard seed, is amply sufficient. Place this on a piece of platinum foil, so bent as to prevent its being blown off, and direct the flame of a spirit-lamp steadily upon it for one or two minutes. The conclusions we are enabled to arrive at by the application of this test, are exceedingly important. Three results occur. First, the calculus is wholly burnt up; secondly, it remains almost entirely unchanged; or thirdly, a part is destroyed while a very decided residue still remains.

If the specimen under examination is entirely lost, we may conclude it consists of either uric acid, urate of ammonia, uric oxide, or cystin.

If on the contrary, it remains almost unchanged, becoming black on the first application of heat and then slightly diminishing, it consists of earthy phosphates, carbonates or oxalates, or of urates with fixed bases, for then the uric acid becomes changed into carbonic, and the size of the specimen does not undergo much diminution.

If on the application of heat, a part of the specimen is consumed, while the remainder undergoes no further change, it consists of a mixture of both the others.

The colour of the flame under the blow-pipe should be noticed. If the calculus burns with a bright, yellow flame, it contains soda, if a pale blue, cystin.

Having obtained this information, we next proceed to distinguish the substances in the different classes from each other. *First Class.*—If the specimen is entirely destroyed by the application of heat, we should take a small portion of the same calculus and place it in a watch-glass. To this, add one or two drops of nitric acid, in which it will dissolve. Evaporate this slowly by means of a gentle heat, and then invert it over another watch-glass, containing a few drops of caustic ammonia. Apply a gentle heat, and if either uric acid or urate of ammonia be present, the rich purple substance called murexid, makes its appearance. If on the contrary, no such change takes place, it is either cystin or uric oxide.

To distinguish between uric acid and urate of ammonia,

take a small quantity finely powdered, and add to it a large quantity of boiling water; if any urate of ammonia be present it will be dissolved, but uric acid alone is unaffected.

If no murexid is formed, we add to the specimen a solution of carbonate of potassa. If it remains undissolved by this, and at the same time disappears under the blow-pipe, it is uric oxide. If, however, it dissolves, it is probably cystin, and this will be rendered certain by ascertaining that another portion of the same calculus dissolves most readily in ammonia, and that after a time it crystallizes from it in six-sided plates, easily recognisable under the microscope. If we wish to be more certain, dissolve a small portion in caustic potash and add so much of a solution of acetate of lead, that all the oxide of lead is held in solution. If this is boiled, from the fact of cystin containing sulphur, a black precipitate of sulphuret of lead is formed, which gives to the liquid the appearance of ink.

Second Class.—Should the specimen under examination undergo little or no diminution of size by the application of heat, we may still be able to note some changes of importance. In the first place, if it undergoes no change at all, it is either the carbonate or phosphate of lime, and the solution of the first in hydrochloric acid before heating it, being attended with effervescence, serves to distinguish it from the other. If it blackens slightly first, then becomes white, (from being converted into a carbonate,) and dissolves in hydrochloric acid, with effervescence, it is oxalate of lime. If, on the contrary, it fuses into an enamel bead,

it is a mixture of phosphate of lime and the triple phosphate, and the more easily this enamel is formed, the nearer are they mixed in equal proportions.

To make sure of these results, we add to a portion of the calculus under consideration, first acetic acid. Should no change take place, it is either the oxalate, phosphate or carbonate of lime, but if it is dissolved, it is the triple phosphate. This conclusion is made more certain by neutralizing the solution with ammonia and adding oxalic acid. No precipitate will then occur. But if to another portion we add ammonia, a copious deposit takes place, which under the microscope, is found to consist of stellar and prismatic crystals.

To those specimens upon which acetic acid has no action, hydrochloric should be added. In this, they quickly dissolve. If with decided effervescence, it is carbonate of lime. If it dissolves at first without, but after heating it on platinum foil with effervescence, it is oxalate of lime, the oxalic acid having been converted into carbonic. But if no effervescence ensues when dissolved in hydrochloric acid, either before or after the application of heat, it is phosphate of lime. When a solution of any of these is made in hydrochloric acid, and then neutralized with ammonia, by the addition of oxalic acid we have precipitated the oxalate of lime.

But as this salt when thus precipitated never appears under the microscope in a sufficiently definite form, to decide with certainty upon its existence, it will be well, in all instances where the oxalate of lime is suspected, to pro-

duce its deposition as it is effected in the urine, that is, by the very gradual addition of ammonia. This may be performed as follows:—Pour the acidulated solution containing the suspected oxalate of lime into a watch-glass, place this in a saucer containing a small quantity of strong ammonia, taking care that the two fluids are not in contact. The ammonia thus unites very gradually with the acid, and if sufficient care be used, the oxalate is precipitated in very large octohedral crystals. Prisms of the triple phosphate may be obtained by the same mode.

Third Class.—When a part of the specimen is consumed under the blow-pipe, while the other undergoes no change, it consists as we have already said of a mixture of both the others. In fact, calculi composed of one of the substances only, we have just enumerated, are very rare, for although in one class, the largest constituent may be uric acid, in another, oxalate of lime, and in a third, the phosphates, yet they are generally mixed with each other in variable proportions. For instance, uric acid and urate of ammonia are very frequently found in calculi consisting almost entirely of phosphates or oxalate of lime; and except in one instance, neither phosphate of lime or the ammoniaco-magnesian phosphate have ever been found as the sole constituent of a urinary calculus.

A TABLE

OF THE CHEMICAL CONSTITUTION OF THE PRINCIPAL SUBSTANCES REFERRED TO IN THIS WORK.

Blood and muscular flesh, . . .	C_{48}	N_6	H_{39}	O_{15}	
Protein, ...	C_{48}	N_6	H_{36}	O_{14}	
Bile, human, ...	C_{50}	N_2	H_{45}	O_{10}	
Choleic acid, ...	C_{76}	N_2	H_{66}	O_{22}	
Kreatine, ...	C_8	N_3	H_{11}	O_6	
Kreatinine, ...	C_8	N_3	H_7	O_2	
Sarcosin, ...	C_6	N_1	H_7	O_4	
Inosinic acid, ...	C_{10}	N_2	H_6	O_{10}	$+HO$
Urea, ...	C_2	N_2	H_4	O_2	
Uric acid, ...	C_{10}	N_4	H_4	O_6	
Hippuric acid, ...	C_{18}	N_1	H_8	O_5	$+HO$
Cystin, ...	C_6	N_1	H_6	O_4	$+S_2$
Murexid, ...	C_{12}	N_5	H_6	O_8	
Benzoic acid, ...	C_{14}		H_5	O_3	
Acetic acid, ...	C_4		H_3	O_3	$+HO$
Lactic acid, ...	C_6		H_5	O_5	$+HO$
Starch, ...	C_{12}		H_{10}	O_{10}	
Sugar of canes, ...	C_{12}		H_9	O_9	$+2HO$
Sugar of grapes, analogous to glucose, .	C_{12}		H_{12}	O_{12}	$+2HO$
Oxalic acid, ...	C_2			O_3	
Carbonic acid, ...	C_1			O_2	
Ammonia, ...		N_1	H_3		
Water, ...			H_1	O_1	

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